APPENDIX O

Summary of Indicator Identification and Ranking Process

APPENDIX O-1

Vital Signs Indicator Identification Workshops

Vital Signs Indicator Identification Workshops

The SFCN held three Vital Signs Indicator Development Workshops in FY06. Two of these were held in South Florida, the first dealing with South Florida bays & marine areas (Jan. 18-19), while the second focused on South Florida uplands & wetlands (Feb. 1-2). The third workshop was held in St. Croix and focused on both uplands & marine areas (Mar. 6-7). The 70 participants (see Appendix O.2) in the 3 workshops included NPS managers and staff, non-NPS natural resource managers and agency staff, and area scientists.

Each workshop was organized to review the SFCN conceptual models and identify potential vital signs indicators to meet the goals of the NPS Inventory and Monitoring Program to:

- Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
- Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
- Provide data to meet certain legal and congressional mandates related to natural resource protection and visitor enjoyment.
- Provide a means of measuring progress towards performance goals.

Workshop participants completed indicator worksheets for each of the high priority indicators identified by their workshop group (Figure 1). Essential information requested on the worksheet included: monitoring question, indicator name, ecosystem type, metric, methods (including frequency, timing and scale), basic assumptions, constraints, and references (Figure 1).

Workshop summaries and related information have been posted to the SFCN website (http://www.nature.nps.gov/im/units/SFCN/ products.htm#vitalsigns).

<u>Post-Workshop Editing</u>

Indicator worksheets from the workshops and a few received after the workshops were reviewed by members of the SFCN staff and edited for clarity and consistency. Worksheet authors were informed in the case of major edits. Indicators produced by different workgroups that were highly redundant in purpose, scope, and methodology were consolidated. A justification section was added to each indicator to make them more understandable to persons who had not attended the workshops.

<u>Vital Signs Indicator Database</u>

All available information from the indicator worksheets (Figure 1) was entered into a network database developed by the Network Data Manager and based on a data structure provided by the National Monitoring Coordinator. This database in turn was used as the foundation for the network's web-based vital signs indicator ranking tool.

Figure 1. SFCN indicator worksheet template with category definitions.

Indicator Worksheet

Who worked on this indicator worksheet (so we can call you with questions):

Indicator: *Specific indicator to monitor*

Monitoring Question(s): *Monitoring question(s) that will be addressed*

Which conceptual model(s) is this indicator linked to?

- ☐ 2.3 Freshwater Wet Prairies and Marshes Ecological Zone
- ☐ 2.4 Forest Uplands and Wetlands Ecological Zone
- ☐ 2.5 Island Interior Ecological Zone
- ☐ 2.6 Mangroves, Beaches & Tidal wetlands Ecological Zone
- ☐ 2.7 Florida Bay Ecological Zone
- ☐ 2.8 Biscayne Bay Ecological Zone
- ☐ 2.9 Coastal Shelf / Deep Oceanic Ecological Zone

Which parks are associated with this indicator?

South Florida Parks

- ☐ Big Cypress National Preserve (BICY)
- ☐ Biscayne National Park (BISC)
- ☐ Dry Tortugas National Park (DRTO)
- ☐ Everglades National Park (EVER)

U.S. Virgin Islands Parks

- ☐ Buck Island Reef Natl. Monument (BUIS)
- ☐ Salt River Nat. Hist. Park & Ecol. Res. (SARI)
- ☐ Virgin Islands National Park (VIIS)

Metric: *Refers to the elements to be measured and the data to be collected*

Method: *Short description of a methodology or references a developed protocol*

Frequency: *Stipulates how often the indicator should be measured*

- ☐ Continuous
- ☐ Monthly
- ☐ Annual
- ☐ Every ______ Years
- ☐ Other (Please specify):

Timing: *Specifies the time of year that data collection should occur*

Scale of Collection: *Scale at which data should be collected*

- ☐ Regional (incl. areas outside parks)
- ☐ Park-wide _______________
- ☐ Other (Please specify):
- ☐ Multiple Parks
- ☐ Site Specific___________________

Scale of Process or Element Operation: Scale *at which the process or element operates*

- ☐ Regional (incl. areas outside parks)
- ☐ Park-wide _______________
- ☐ Other (Please specify):
- ☐ Multiple Parks
- ☐ Site Specific___________________

Scale of Analysis: *Scale at which analysis can be inferred*

- ☐ Regional (incl. areas outside parks)
- ☐ Park-wide _______________
- ☐ Other (Please specify):
- ☐ Multiple Parks
- ☐ Site Specific___________________

Basic Assumptions: *Specifies the underlying assumption(s) that, if not true, would invalidate this indicator/methodology*

Research Needs: *Identifies any known research need(s) that would facilitate understanding of how this indicator fits within the ecosystem model*

Management Goal: *Desired future condition*

Threshold Target: *Stipulates the resource condition (numerically if possible) and the amount of variation from this condition that will be tolerated (accepted as natural variation). If insufficient knowledge exists, say "insufficient knowledge".*

Response*:* *Specifies what management action is recommended if the threshold or target is not met*

Constraints: *Lists issues/concerns about the indicator related to its successful implementation*

Status: *Identifies whether monitoring is proposed, in development, or on-going*

Estimated cost: *Rough estimate of cost, either in total or per sample, per replicate, etc.*

References: Contacts, *experts or literature relevant to the indicator (continue on back if necessary)*

The SFCN database was linked to dynamic web pages posted on the network web site using a system that had been previously developed by the San Francisco Bay Area Network (SFAN) and successfully used by both the SFAN as well as the Mediterranean Coast Network (MEDN). This linkage allowed revisions to the database to be immediately incorporated into the web page. However the primary purpose was to use the linked web pages as the SFCN ranking instrument.

Selection of Ranking Participants

Over 130 persons, including previous workshop invitees, NPS resource management staff, and additional area scientists and agency staff representing a diverse array of specialty areas, were invited to use the web-based database tool to rank the network's indicators. These invitees were also asked to spread information about the ranking process to friends and colleagues and invite them to participate as well. The 102 people who participated in the ranking process are listed in Appendix O-3.

Criteria for Prioritizing Vital Signs

The four criteria utilized to rank vital signs indicators reflect important qualities of an effective vital signs monitoring program and were modified from the Cumberland-Piedmont Network ranking criteria, Jackson et al. (2000), Tegler et al. (2001), and Andreasen et al. (2001) (Figure 2). "Legal Mandate" and "Management Significance" criterion were ranked by SFCN staff and then forwarded to each park for review and correction. "Ecological Significance" and "Feasibility" were ranked via the on-line ranking process.

Initial Ranking Process and Ranking Instrument

The initial ranking process was conducted using a web-based ranking methodology. The SFCN database and associated web pages functioned as the source of indicator ranking information and as the receptacle for ranking scores and participant comments.

Participants from previous workshops, additional subject experts, regional NPS staff, and other selected agency officials were sent a background statement, instructions, and descriptions of the ranking process via email. All invited participants were given a password, giving them access to the ranking website (www.nature.nps.gov/im/units/SFCN/Ranking.htm) which also contained links to background and instructional materials. Login names and passwords were used to provide sufficient security during the ranking process. Upon reviewing the instructions and ranking criteria, participants were asked to rank each indicator from "very low" to "very high" with respect to "Ecological Significance" and "Feasibility" (Figure 3). Participants also had the option of choosing "no opinion" for each criterion if they had insufficient knowledge about the indicator to evaluate it. Participants could view the existing information for each indicator, print any or all of the information, rank indicators in accordance with the SFCN criteria, review their scores, and change them as often as the participants wished during the three week window that the database was open. Ranking instructions sent to all participants are included in Appendix O-4.

Figure 2. Criteria for prioritizing South Florida / Caribbean Network indicators.

Primary Criteria	Sub-criteria*	Prioritization Scheme
Ecological Significance	a) <u>Ecological Importance:</u> The indicator represents a resource or function of high ecological importance based on conceptual models and/or literature. b) <u>Good indicator of system resource or function:</u> There is a strong, defensible linkage between the indicator and the ecological function or critical resource it is intended to represent. c) <u>Early warning/sensitive to change:</u> The indicator provides early warning of undesirable changes to important resources. d) <u>Supporting data/scientific work:</u> Reference conditions exist within the region, and/or threshold values are in available literature e) <u>Connectivity:</u> The indicator affects/responds to ecological processes at other spatial scales and levels of biological organization	*<u>Very High</u>*—I **strongly agree** with all **5** of these statements. *<u>High</u>*—I **strongly agree with 4** of these statements *<u>Moderate</u>*—I **strongly agree with 3** of these statements *<u>Low</u>*—I **strongly agree** with **2** of these statements. *<u>Very Low</u>*--This is an important indicator to monitor, but I **do not strongly agree** with more than 1 of these statements. *<u>No opinion</u>*--I do not know enough about this criterion for this indicator to rank it.
Feasibility	a) <u>Well-documented rigorous protocols:</u> Well-documented, scientifically sound monitoring protocols already exist for the indicator. b) <u>Technically feasible:</u> Implementation of monitoring protocols is feasible given the constraints of site accessibility, sample size, equipment maintenance, etc. c) <u>Interpretable:</u> The indicator is sensitive to change and has a high signal to noise ratio that can be distinguished from naturally occurring variability. Results are repeatable with different qualified personnel. d) <u>Low-cost:</u> Sampling and analysis techniques are doable with low to moderate cost relative to information gained. e) <u>Cost-sharing opportunities:</u> The opportunity for cost-sharing partnerships with existing NPS monitoring, other agencies, universities, or private organizations in the region exists.	*<u>Very High</u>*—I **strongly agree** with all **5** of these statements. *<u>High</u>*—I **strongly agree with 4** of these statements *<u>Moderate</u>*—I **strongly agree with 3** of these statements *<u>Low</u>*—I **strongly agree** with **2** of these statements. *<u>Very Low</u>*--This is an important indicator to monitor, but I **do not strongly agree** with more than 1 of these statements. *<u>No opinion</u>***—**I do not know enough about this criterion for this indicator to rank it.

Primary Criteria	Sub-criteria*	Prioritization Scheme
Management Significance	a) <u>Relevant to key management decisions:</u> There is an obvious, direct application of the data to a key management decision(s), or for evaluating the effectiveness of past management decisions (can include performance towards (GPRA) goals and/or park Strategic Plans). b) <u>Early warning:</u> Monitoring results are likely to provide early warning of resource impairment. c) <u>Allow better-informed management:</u> Data are badly needed to give managers a better understanding of park resources so that they can make informed decisions. d) <u>Clearly understood:</u> The indicator will produce results that are clearly understood and accepted by park managers, other policy makers, research scientists, and the general public. e) <u>Public interest:</u> Data are of high interest to the public.	<u>*Very High*</u>—I **strongly agree** with all **5** of these statements. <u>*High*</u>—I **strongly agree with 4** of these statements <u>*Moderate*</u>—I **strongly agree with 3** of these statements <u>*Low*</u>—I **strongly agree** with **2** of these statements. <u>*Very Low*</u>--This is an important indicator to monitor, but I **do not strongly agree** with more than 1 of these statements. <u>*No opinion*</u>—I do not know enough about this criterion for this indicator to rank it.
Legal Mandate	This criterion is part of 'Management Significance' but is purposely duplicated here to emphasize those indicators and resources that are required to be monitored by some legal or policy mandate. The intent is to give additional priority to an indicator if a park is directed to monitor specific resources because of some binding legal or Congressional mandate, such as specific legislation and executive orders, or park enabling legislation. The binding document may be with parties at the local, state, regional, or federal level.	<u>*Very High*</u>—<u>Legal requirement:</u> The park is **required** to monitor this specific resource/ indicator by some specific, binding, legal mandate (e.g., Endangered Species Act for an endangered species, Clean Air Act for Class 1 airsheds, Clean Water Act). <u>*High*</u>—<u>Executive Order, Mandate, Park Enabling Legislation:</u> The resource/indicator is specifically covered by an Executive Order (e.g., invasive plants, wetlands) or Mandate, or specifically identified in park enabling legislation. <u>*Moderate*</u>— <u>Goal</u>: There is a GPRA goal specifically mentioned for the resource/indicator being monitored, or the need to monitor the resource is generally indicated by some type of federal or state law (e.g. CERP). <u>*Low*</u>— <u>Concern:</u> The resource/indicator is listed as a sensitive resource or resource of concern by credible state, regional, or local conservation agencies or organizations, but it is not specifically identified in any legally-binding federal or state legislation. <u>*Very Low*</u>— The resource/indicator is covered by the Organic Act and other general legislative or Congressional mandates such as the Omnibus Park Management Act and GPRA, and by NPS Management Policies, but there is no specific legal mandate for this particular resource. <u>*No opinion*</u>—I do not know enough about this criterion for this indicator to rank it.

Additionally, participants were given two locations in which to provide feedback. The comment box under the ranking scores could be used to explain ranking scores. A second comment box was intended for information on citations or methods that were not included in the worksheet. Comments were taken into consideration as indicator ranking results were analyzed and will be considered during protocol development.

Figure 3 depicts an example ranking dialog box for the Invasive exotic plants indicator. Within the dialog box, underlined text provided hyperlinks to protocol database information for the indicator as well as descriptive information for each ranking criterion. Protocol information specific to each indicator was found immediately below the dialog box on the ranking website.

Figure 3. Example of an indicator ranking dialog box for the indicator "Invasive Exotic Plants." Underlined text indicates a hyperlink to descriptive materials.

Invasive exotic plants	Ecological: ☐ Very High ☐ High ☐ Medium ☐ Low ☐ Very Low ☐ No Opinion Feasibility: ☐ Very High ☐ High ☐ Medium ☐ Low ☐ Very Low ☐ No Opinion Management: Very High Legal: High Rank

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

SFCN Web-based Ranking Results

Participant Response Rate

Of the 130+ people invited to rank the proposed SFCN vital signs, 102 people participated. Thirty-three (33) of the 102 participants were NPS employees and 69 were non-NPS scorers. It should be noted that not all people who participated in the prioritization process ranked all 69 indicators. The participants are listed in Appendix O-3.

Ecological Significance and Feasibility

Ecological and Feasibility were ranked via the web-based ranking process.

Management Significance and Legal Mandate

Management and Legal scores were developed by SFCN staff, following criteria listed in Figure 2, and then submitted to each park for review.

Calculation of Ecological-Feasibility Index (EF Index)

The 69 SFCN indicators were ranked by creating a weighted index from the average "Ecological Significance" score and average "Feasibility" score. For each indicator, scores were first converted to numerical values with "Very High" = 5 and "Very Low" = 1. Then average scores were calculated across all respondents for each of "Ecological Significance" and "Feasibility." These scores were then combined in a weighted index as follows:

EF Index =2*(Average Ecological Score) + (Average Feasibility Score)

The results are given in Table 1. Please note that the number of responses(scores) for each indicator varied since not all participants ranked all of the indicators. Only rankings of "Very High" to "Very Low" were included in the calculation of the averages. Non-responses or "No Opinion" responses were not included.

Alternative Ecological-Feasibility-Management-Legal Index (EFML Index)

"Management Significance" and "Legal Mandate" scores were assigned by SFCN. An alternative EFML index was created by adding these scores to the EFML index as follows:

EFML Index = EF Index + Management Score + Legal Mandate Score

A Majority of indicators were ranked under Management Significance as Very High (35/69) or High (11/69), reflecting that the workshops had produced many indicators highly relevant to management. However this meant Management Significance had little affect in changing scores and that Legal Mandate, whose scores ranged more widely, produced much of the changes in the EFML Index from the previously described EF Index. Federally listed species (e.g. Florida Panther, Colonial Nesting Birds), marine fish communities, and water quality indicators all received boosts in the rankings compared with the EF Index. In contrast, 11 vegetation indices, 2 amphibian indices, and 2 exploited communities were ranked lower under the EFML index.

SFCN staff chose to focus on the EF Index as the ranking index for all additional queries described below for the following reasons:

- The Management Significance and Legal Mandate scores had only received minimal review from the parks due to a limited review window
- Legal Mandate played a large role in changes in the index,
- Management Significance played a small role in changes in the index,
- The primary purpose of the program is to monitor ecosystem condition rather than legal mandates.

Key Assumptions and Biases

The SFCN vital signs selection and prioritization process is not a perfect representation of a rigorous scientific study. Rather, it was designed as tool to assist decision-makers in distilling complex natural resource management issues into a ranked list of indicators to assist final selection of vital signs for a flexible yet effective monitoring program. The SFCN prioritization process, therefore, has several inherent assumptions and biases. Consequently, interpretation of the results has been complicated by the fact that:

- We assumed all significant management issues have been captured,
- We assumed all significant indicators have been represented,
- We assumed all perspectives have been represented,
- We assumed descriptive statistics were adequate for ranking the SFCN vital signs,
- Participating scorers were a pre-selected group (i.e., not random),
- Participants were, for the most part, selected by the SFCN,
- Not all data fields were complete for each indicator,
- The sample size (number of people who scored indicators) was low (102 total participants; median for any one indicator=42 scores; smallest was 22 scores),
- The number of scorers (N) varied for each indicator (22-69 scores/indicator), and
- Response rate for each indicator may have been affected by the order of the list of indicators (ordered according to national I&M categories).

A summary of the actual number of scores by rank category "Very High", "High", "Medium", "Low", and "Very Low" is shown in Table 2. This table shows the distribution of the actual scores and standard deviation.

<u>Additional Sorts and Data Comparisons</u>
Additional sorts and comparisons were conducted:

Table 3 shows a comparison of rankings using the EF Index, EFML Index and "Ecological Only" ranking.

Table 4. Splits indicators into "Uplands and wetlands" vs "Bays and Marine" lists and compares them side by side using the EF Index and listing the original ranks from Table 1.

Table 5. Creates two list of indicators based on the EF Index compared side by side:

Florida indicators (excludes USVI only indicators) ranked by participants claiming a Florida specialty.

USVI indicators (excludes (Florida only indicators) ranked by participants claiming a Caribbean specialty.

Table 6 Compares the rankings of NPS staff and non-NPS participants side by side.

Table 7 Shows rankings of indicators relevant to each park based on EF Index.

Appendix O-2

List of Participants
Vital Signs Indicator Identification Workshops

Appendix O-2. List of participants in Vital Signs Indicator Identification Workshops January18-19, 2006 Vital Signs Prioritization Meeting. South Florida bays & marine areas. February 1-2, 2006 South Florida uplands & freshwater wetlands. Mar. 6-7 St. Croix uplands & marine areas.

Workshop	First Name	Last Name	Company Name
All	Andrea	Atkinson	NPS- SFCN
All	Matt	Patterson	NPS- SFCN
All	Kevin	Whelan	NPS- SFCN
All	Brian	Witcher	NPS- SFCN
Marine	Richard	Alleman	South Florida Water Management District, Planning Department
Marine	Jerry	Ault	Marine Biology and Fisheries- RSMAS
Marine	Sarah	Bellmund	Biscayne National Park
Marine	Stephen	Blair	Restoration & Enhancement Section, DERM
Marine	Jim	Bohnsack	NOAA- SEFSC
Marine	Amanda	Bourque	Biscayne National Park
Marine	Joe	Boyer	Southeast Environmental Research Center
Marine	Joan	Browder	NOAA
Marine	Richard	Curry	Biscayne National Park
Marine	Gary	Davis	Channel Islands National Park
Marine	Bob	Halley	USGS Center for Coastal and Watershed Studies
Marine	Todd	Hopkins	US Fish & Wildlife Service
Marine	Brian	Keller	Florida Keys National Marine Sanctuary
Marine	Todd	Kellison	NOAA
Marine	Tonnie	Maniero	National Park Service
Marine	Amar	Nayegandhi	USGS Center for Coastal Watershed Studies
Marine	Amy	Renshaw	
Marine	Mike	Robblee	USGS Biological Resources Division
Marine	Dave	Rudnick	South Florida Water Management District
Marine	Tom	Schmidt	National Park Service
Marine	Joe	Serafy	NOAA Fisheries, Southeast Fisheries Science Center
Marine	Jim	Tilmant	National Park Service, Water Resources Division
Marine	Hal	Wanless	University of Miami- Department of Geological Sciences
Marine&Terrestrial	Judd	Patterson	NPS- SFCN
Marine&Terrestrial	Sasha	Wright	NPS- SFCN
Terrestrial	Rick	Anderson	Everglades National Park
Terrestrial	Pinar	Balci	SFWMD
Terrestrial	Mike	Barry	TTINWR
Terrestrial	Sonny	Bass	Everglades National Park
Terrestrial	Joe	Bozzo	FFWCC
Terrestrial	Keith	Bradley	IRC
Terrestrial	Jim	Burch	Big Cypress National Preserve
Terrestrial	Bob	Doren	NPS- FIU
Terrestrial	Tom	Dreschol	SFWMD
Terrestrial	Evelyn	Gaiser	FIU
Terrestrial	Bob	Howard	Everglades National Park
Terrestrial	Jeff	Kline	Everglades National Park
Terrestrial	Ken	Krauss	USGS
Terrestrial	Sue	Perry	Everglades National Park
Terrestrial	Tom	Philippi	FIU
Terrestrial	Ken	Rice	USGS
Terrestrial	Jenny	Richards	Florida International University
Terrestrial	Mike	Ross	Florida International University
Terrestrial	Jimi	Sadle	Big Cypress National Preserve

Workshop	First Name	Last Name	Company Name
Terrestrial	Len	Scinto	FIU
Terrestrial	Gary	Slater	
Terrestrial	Craig	Smith	Everglades National Park
Terrestrial	Skip	Snow	Everglades National Park
USVI	Rafe	Boulon	Virgin Islands National Park
USVI	Sheri	Caseau	Virgin Islands National Park
USVI	William	Coles	DFW
USVI	Mark	Drew	The Nature Conservancy
USVI	Kurt	Grove	University of Puerto Rico Sea Grant
USVI	Edwin	Hernandez	University of Puerto Rico Sea Grant
USVI	Zandy	Hillis-Starr	Buck Island Reef National Monument/ Salt River NHP&EP
USVI	Roy	Irwin	NPS- Water Resources Division
USVI	Chris	Jeffrey	National Ocean Service
USVI	Ian	Lundgren	Buck Island Reef National Monument/ Salt River NHP&EP
USVI	Violetta	Mayor	USVI- Department of Planning and Natural Resources
USVI	Charlie	Menza	NOAA
USVI	Jeff	Miller	NPS- SFCN
USVI	Shona	Paterson	TNC
USVI	Caroline	Rogers	USGS Caribbean Field Station
USVI	Shauna	Slingsby	NOAA
USVI	William	Tobias	USVI-DPNR
USVI	Wes	Toller	Fish and Wildlife
USVI	Rob	Waara	NPS- SFCN

Appendix O-3

List of Participants
in the
SFCN Web-based Ranking Process

LastName	FirstName	Agency	Speciality Category
Alleman	Rick	South Florida Water Management District	marine ecology/biology
Alvear	Elsa	National Park Service-Biscayne National Park	wildlife ecology/biology
Anderson	Rick	National Park Service-Everglades National Park	plant ecology/botany
Atkinson	Andrea	National Park Service-South Florida /Caribbean Network	plant ecology/botany
Ault	Jerald	Univ. of Miami-RSMAS	marine ecology/biology
Aumen	Nick	National Park Service-Everglades National Park	hydrology/water quality/biogeochemical
Beaver	Carl	Florida Fish & Wildlife Conservation Commission	marine ecology/biology
Bellmund	Sarah	National Park Service-Biscayne National Park	marine ecology/biology
Bodle	Mike	South Florida Water Management District	plant ecology/botany
Bohnsack	James	National Oceanic and Atmospheric Administration	wildlife ecology/biology
Boulon	Rafe	National Park Service-Virgin Islands National Park	marine ecology/biology
Bourque	Amanda	National Park Service-Biscayne National Park	marine ecology/biology
Boyer	Joseph N.	Florida International University	hydrology/water quality/biogeochemical
Bozzo	Joseph	Florida Fish & Wildlife Conservation Commission	wildlife ecology/biology
Bradley	Keith	Institute for Regional Conservation	plant ecology/botany
Caldow	Chris	National Oceanic and Atmospheric Administration	marine ecology/biology
Callahan	Michael	Florida Fish & Wildlife Conservation Commission	marine ecology/biology
Caseau	Sheri	National Park Service-Virgin Islands National Park	marine ecology/biology
Cherkiss	Michael	University of Florida	wildlife ecology/biology
Clark	Daniel	National Park Service-Exotic Plant Management Team	plant ecology/botany
Clark	Ron	National Park Service-Big Cypress National Preserve	wildlife ecology/biology
Davidson Hile	Sarah	National Oceanic and Atmospheric Administration	marine ecology/biology
Davis	Gary	National Park Service	marine ecology/biology
Dong	Quan	National Park Service-Everglades National Park	wildlife ecology/biology
Doren	Robert	Florida International University	plant ecology/botany
Dreschel	Thomas	South Florida Water Management District	hydrology/water quality/biogeochemical
Drew	Mark	The Nature Conservancy	marine ecology/biology
Engel	Vic	National Park Service-Everglades National Park	hydrology/water quality/biogeochemical
Gaiser	Evelyn	Florida International University	plant ecology/botany
Geselbracht	Laura	The Nature Conservancy	marine ecology/biology
Grove	Kurt	University of Puerto Rico Sea Grant	geology
Hernandez	Edwin	University of Puerto Rico	wildlife ecology/biology
Halley	Robert	U. S. Geological Survey	geology
Hillis-Starr	Zandy	National Park Service-Buck Island Reef National Monument	wildlife ecology/biology
Hopkins	Todd	U. S. Fish & Wildlife Service	marine ecology/biology
Hunt	John	Florida Fish & Wildlife Conservation Commission	marine ecology/biology
Irwin	Roy	National Park Service-WRD	hydrology/water quality/biogeochemical

LastName	FirstName	Agency	Speciality Category
Jansen	Deborah	National Park Service-Big Cypress National Preserve	wildlife ecology/biology
Jeffery	Brian	University of Florida	wildlife ecology/biology
Jeffrey	Christopher	National Oceanic and Atmospheric Administration	marine ecology/biology
Johnson	Ed	National Oceanic and Atmospheric Administration	hydrology/water quality/biogeochemical
Johnson	Robert	South Florida Water Management District	wildlife ecology/biology
Kearns	Edward	National Park Service-Everglades National Park	physical/chemical oceanography
Keller	Brian	National Oceanic and Atmospheric Administration	marine ecology/biology
Kellison	Todd	National Oceanic and Atmospheric Administration	marine ecology/biology
Kendall	Matt	National Oceanic and Atmospheric Administration	marine ecology/biology
Kline	Jeff	National Park Service-Everglades National Park	wildlife ecology/biology
Krauss	Ken	U. S. Geological Survey	plant ecology/botany
Loomis	Christy	National Park Service- Virgin Islands National Park	wildlife ecology/biology
Maniero	Tonnie	National Park Service	hydrology/water quality/biogeochemical
Mayor	Philippe	USVI DPNR	marine ecology/biology
Mazzotti	Frank	University of Florida	wildlife ecology/biology
McDevitt	Erin	Florida Fish & Wildlife Conservation Commission	marine ecology/biology
Menza	Charles	National Oceanic and Atmospheric Administration	marine ecology/biology
Miller	Jeff	National Park Service-South Florida /Caribbean Network	marine ecology/biology
Morrison	Douglas	National Park Service-Everglades National Park	marine ecology/biology
Muller	Erinn	U. S. Geological Survey	marine ecology/biology
Nemeth	Rick	University of Virgin Islands	marine ecology/biology
Oberhofer	Lori	National Park Service-Everglades National Park	wildlife ecology/biology
Pait	Tony	National Oceanic and Atmospheric Administration	hydrology/water quality/biogeochemical
Patterson	Matt	National Park Service-South Florida /Caribbean Network	marine ecology/biology
Pernas	Tony	National Park Service-Exotic Plant Management Team	plant ecology/botany
Perry	Sue	National Park Service-Everglades National Park	wildlife ecology/biology
Philippi	Tom	Florida International University	plant ecology/botany
Pittman	Simon	National Oceanic and Atmospheric Administration	marine ecology/biology
Pratt	Paul	U.S. Department of Agriculture	plant ecology/botany
Ray	Gary	University of Virgin Islands	plant ecology/botany
Renshaw	Amy	National Park Service-Biscayne National Park	hydrology/water quality/biogeochemical
Rice	Ken	U. S. Geological Survey	wildlife ecology/biology
Richards	Jennifer	Florida International University	wildlife ecology/biology
Rivera-Monroy	Victor	LSU	hydrology/water quality/biogeochemical
Rogers	Caroline	U. S. Geological Survey	marine ecology/biology
Ross	Michael	Florida International University	plant ecology/botany

LastName	FirstName	Agency	Speciality Category
Rutchey	Ken	South Florida Water Management District	plant ecology/botany
Schall	Ted	South Florida Water Management District	wildlife ecology/biology
Schittone	Joe	National Oceanic and Atmospheric Administration	marine ecology/biology
Schmidt	Tom	National Park Service-Everglades National Park	marine ecology/biology
Scinto	Len	Florida International University	hydrology/water quality/biogeochemical
Shoemaker	Wayne	U. S. Geological Survey	hydrology/water quality/biogeochemical
Slingsby	Shauna	National Oceanic and Atmospheric Administration	marine ecology/biology
Smith	Craig	National Park Service-Everglades National Park	plant ecology/botany
Smith	Jacqueline		plant ecology/botany
Smith	Kent	Florida Fish & Wildlife Conservation Commission	marine ecology/biology
Smith	Tyler	University of Virgin Islands	marine ecology/biology
Smith III	Thomas	U. S. Geological Survey	marine ecology/biology
Snow	Skip	National Park Service-Everglades National Park	wildlife ecology/biology
Spitzack	Anthony		marine ecology/biology
Taylor	Christine	Florida International University	marine ecology/biology
Taylor	Marcia	University of Virgin Islands	marine ecology/biology
Thomas	Serge	Florida International University	marine ecology/biology
Tobias	Franco	FIU	wildlife ecology/biology
Tobias	William	USVI DPNR-Fish and Wildlife	marine ecology/biology
Troxler-Gann	Tiffany	Florida International University	hydrology/water quality/biogeochemical
Ugarte	Cristina	University of Florida	wildlife ecology/biology
Verdon	Emilie	Institute for Regional Conservation	wildlife ecology/biology
Waara	Robert	National Park Service-South Florida /Caribbean Network	marine ecology/biology
Weil	Ernesto	University of Puerto Rico	marine ecology/biology
Whelan	Kevin	National Park Service-South Florida /Caribbean Network	hydrology/water quality/biogeochemical
Whitall	Dave	National Oceanic and Atmospheric Administration	hydrology/water quality/biogeochemical
Woodmansee	Steve	Institute for Regional Conservation	plant ecology/botany
Woody	Kimberly	National Oceanic and Atmospheric Administration	marine ecology/biology
Zimmerman	Mike	National Park Service-Everglades National Park	hydrology/water quality/biogeochemical

Appendix O-4

Web-based Ranking Instructions

South Florida/Caribbean Network
Vital Signs Indicator Ranking

Welcome! We want to thank you for participating in the South Florida/Caribbean Inventory and Monitoring Network's Vital Signs ranking process and assistance in developing a large-scale, long-term ecological monitoring program for the National Parks in both South Florida and the U. S. Virgin Islands! We realize how valuable your time is and we sincerely appreciate your participation in this endeavor.

Ranking Process: Sixty-nine potential indicators were identified during a series of 3 NPS Vital Signs indicator identification workshops. These indicators need to be ranked to assist selection of a good sub-set of indicators that will be monitored as "Vital Signs". Each of the 69 indicators will be ranked in 4 separate categories using ranking criteria:

Ranking Category	Your role
Ecological Significance	Ranking
Feasibility	Ranking
Management Significance	Comments
Legal Mandate	Comments

We are asking your assistance in ranking "Ecological Significance" and "Feasibility". SFCN staff drafted rankings for "Management Significance" and "Legal Mandate" and are asking park management to review those rankings in a parallel process. However we would appreciate comments if you feel the rankings should be adjusted. Comments on the details of the indicators are also appreciated.

Your rankings must be entered by **April 26** to be included in the ranking summary analysis.

If you know of additional experts whom you feel should be included in the ranking process, please let them know about this web page. We want a wide range of experts to rank the vital signs. However we request that you not simply forward this web page to general list servers.

Directions:

1. Click on the "Continue to Ranking" link below and identify yourself by entering your personal information in the blanks provided.
2. Print out and read the criteria for prioritizing indicators carefully and refer back to it when ranking.
3. The indicators are shown as a long list and similar topics are grouped together. You don't need to stick with that pattern when completing this activity. We have created a checkoff sheet that lists all the indicators that you can print out and use to check-off indicators completed.
4. Read all of the information provided about the indicators before ranking, especially the monitoring questions, justification, metric, and methodology. This will reduce ranking based

solely on assumptions taken from the name of the indicator. For acronym definitions click here.
5. Rank each indicator criteria from very low to very high. We consider all of these indicators important. However the intent of the criteria is to produce a range of scores rather than having everything rank “very high”. Please ask yourself if you “strongly agree” about the criteria for a given indicator and this should help with the ranking. The no opinion value should be used if you don't know enough about the criteria or indicator to rank it.
6. After ranking the first indicator, return to the main page and select the next indicator of your choice. You may rank them in any order you choose. You do not need to rank all indicators (although it would be helpful if you would).
7. You may log-in to the site as many times as necessary to finish ranking or change your scores.

Click Below to

!!! Proceed to Ranking !!!

Background and FAQ: For additional background and frequently asked questions about the workshops and Vital Signs selection process, click here.

Technical Support: If you have any questions about the process, or run into any problems, please contact our Data Manager, Brian Witcher at Brian_witcher@nps.gov or at 305-252-0347.

* Parks include: Big Cypress National Preserve (BICY); Biscayne National Park (BISC); Buck Island Reef National Monument (BUIS); Dry Tortugas National Park (DRTO); Everglades National Park (EVER); Salt River National Historic Site and Ecological Preserve (SARI); and Virgin Island National Park (VIIS)

Appendix O-5

Vital Signs Ranking Meeting

South Florida / Caribbean Network Meeting Summary
Vital Signs Ranking Meeting
May 9-10, 2006
St. Croix, USVI

Meeting participants

Park Staff:
- Art Frederick (VIIS)
- Craig Smith (EVER, DRTO)
- Dan Kimball (EVER, DRTO)
- Elsa Alvear (BISC)
- Ian Lundgren (BUIS, SARI)
- Joel Tutein (BUIS, SARI)
- Karen Gustin (BICY)
- Larry West (SERO)
- Mark Lewis (BISC)
- Ron Clark (BICY)
- Thomas Kelley (VIIS)
- Zandy Hillis-Starr (BUIS, SARI))

SFCN Staff
- Matt Patterson
- Jeff Miller
- Andrea Atkinson
- Kevin Whelan
- Brian Witcher
- Rob Waara
- Judd Patterson
- Sasha Wright

Meeting purpose – To review network indicator ranking and achieve agreement on a prioritized list of Vital Sign indicators for the South Florida/Caribbean Network long-term monitoring program.

Meeting Objectives:
1.) Provide update on network activities
2.) Provide overview of indicator development
3.) Review ranking results
4.) Develop and achieve agreement upon a prioritized list of Vital Signs Indicators
5.) Discuss how best to implement Vital Signs monitoring for selected indicators

Handouts

Each attendee received a notebook containing: Workshop Agenda, Ranking Methodology, Ranking Results (7 tables), Draft SFCN Timeline, Phase 3 Report Outline, Park-specific Conceptual Models (BUIS only presented), SFCN Briefings - Handouts on SFCN informational presentations, Indicator Worksheets

An additional handout was made during the workshop showing indicators first organized under general topics and then sorted by ranking (see attached).

Results from the online indicator ranking

Results from the online indicator ranking for Ecological Significance and Feasibility were presented. The primary ranking index proposed was the "EF Index"

EF Index = 2 * (Average Ecological Significance score) + (Average Feasibility Score)

An alternate index was also presented

EFML Index = EF Index + Management Score + Legal Score

SFCN staff recommended using the EF index because

- The Management Significance and Legal Mandate scores had only received minimal review from the parks due to a limited review window,
- Legal Mandate played a large role in changes in the index, moving threatened species, endangered species and water quality indicators higher on the list,
- Management Significance played a small role in changes in the index with over 2/3 of the indicators ranking as “High” or “Very High,”
- The primary purpose of the program is to monitor ecosystem condition rather than legal mandates.

The meeting participants agreed to use the EF Index as the initial ranked list and the basis for further discussion.

Various methods of looking at the indicator lists were presented:

- Distribution of scores and indicators that had widest variance in rankings,
- Separation of Bay & Marine Indicators from Uplands & Wetlands Indicators,
- Rankings of Florida indicators (by Florida only specialists) compared with rankings of USVI Indicators (by Caribbean only specialists),
- NPS staff rankings compared with non-NPS staff,
- Park-specific queries which included only indicators checked for each park,
- Effects of people who only ranked < 10 indicators.

Participants were told that SFCN plans to use the ranked list to build the best I & M program possible by following ranks as much as possible, but also looking for

- Opportunities to collaborate (e.g. CERP, parks listed-species monitoring, NOAA),
- Opportunities where co-location or other techniques can reduce costs,
- Suites of indicators that provide added value (e.g. veg plots with herpetofauna sampling).

Indicators will be reported to Park Management, Congress, Public (and Scientific Community was added by participants)

Meeting participants were then asked:

- Is anything important missing?
- Is there anything missing from top 20?
- What (if anything) should be shifted?

These questions formed the basis for further discussion.

Combining indicators

Concerns were expressed that some indicators overlap and perhaps should be lumped. SFCN agreed to review the water quality indicators (#5, #7, #11, #12, #18, #25), exotic fauna indicators (#17, #20), sea turtle indicators (#27, #34) and marine fish communities indicators (#21, #36, #42, #46, #50) and make recommendations regarding combining indicators (see Table 1).

SFCN staff reviewed the indicators and on day 2 of the workshop recommended combining the marine fish communities-bays/mangroves indicators (#21, #36, #42, #46, #50) as these all relate to the same indicator but show different methods. SFCN staff did not recommend combining the other indicators, especially the water quality indicators, as they referred to very different things with very different methodologies. Combining these indicators would not simplify the list as the costs of monitoring would remain the same.

Superintendents agreed that they were basically happy with the top 20 listed indicators.

Moving indicators below the top 20

For indicators below the top 20, each superintendent was asked to propose indicators they would like to see moved higher on the list. These indicators were listed and each superintendent was asked to vote twice for those indicators they felt most strongly about. After the votes were tallied, the indicators were discussed regarding moving them on the list, why, why not, what other indicators should be moved down, combined, etc.

Initial rank	Indicator name	# votes
30	Benthic Communities(mapping)	3
67	USVI Bats	2
26	Long-term within community vegetation plots	2
40	Landbirds-Residential & Migratory	2
25	Contaminants	2
68	Butterflies	1
61	USVI Amphibians	1
23	Periphyton	1
21	Marine Fish Communities – Bays & Mangroves	1
52	Mudbanks, berms	0
64	USVI Reptiles	0
43	Location of hammock/pineland ecotones	Combined with #22 before voting

Indicator “Location of hammock/pineland ecotones” (initial rank=43) was combined with “Location of Critical Ecotones – field plots/transects” (initial ranked=22). Location of Hammock/pineland ecotones is an important indicator for BICY.

“Landbirds-Residential and migratory” (initial rank=40) was moved to rank 31. Migratory and residential birds are in the enabling legislation of several of the parks (EVER, BICY, DRTO). Birds are also of high interest to many visitors. In addition there needs to be some more “terrestrial” indicators higher in the list. Birds are early indicators of change and monitoring protocols are available. With climate change, migratory bird arrival date can be expected to change.

USVI amphibians (initial rank=61) were combined with “South Florida amphibians” (initial rank=37) into a network-wide “Amphibians – south Florida and USVI” indicator and moved to a revised rank of 32. It was felt that the combined indicator would have ranked higher than the separately listed indicators if it had originally been listed that way.

Spiny Lobster (initial rank=31) was combined with “Exploited invertebrates” (initial rank=13) (this came up when the group was deciding which indicators to move down).

The other indicators listed were discussed, but their order on the list was left unchanged.

“USVI Bats” (initial rank=67) generated discussion as this was considered an important indicator for VIIS. However it was agreed that this was primarily a VIIS issue and would remain where it was on the list. VIIS is hiring a new biological technician who could initiate bat monitoring, but would appreciate guidance from SFCN.

Butterflies (initial rank=68) were discussed. Butterflies could be indicators of whether fire regimes are right, vegetation composition, and mosquito control impacts. However SFCN staff brought up that butterflies are difficult to monitor well and that 7 of 9 other networks which had identified butterflies had eventually dropped them as too difficult to monitor well.

Periphyton (initial rank= 23) – BICY wanted to see this indicator expanded into their park. It is a CERP indicator and will be monitored in Everglades. Ranking was left the same.

Contaminants (initial rank= 25) – Meeting participants agreed that this indicator is important but with current funding I&M can't approach funding this indicator; SFCN should instead focus on collaborating with other agencies and networks and not funding additional contaminants work at this time.

Other comments on indicators
Concerns were expressed that there were so many water quality indicators in the top 20.

Question was raised regarding where sea level rise and tidal stage are included. Response was under hydrology (initial rank=3) as well as under indicators “Location of critical ecotones - field plots/transects” (initial rank=22), “Ecotone shifts along wetland boundaries - Mangrove to marsh to cypress- Aerial photography” (initial rank=32), “Sediment elevation in mangroves and mud banks (Fl Bay) Salt Ponds (USVI) and Mangroves fringes” (initial rank=33), “Physical drivers of mangrove-marsh ecotones” (initial rank=35).

The value of sea turtles (initial rank=27) as an ecosystem indicator was questioned. While a popular species, sea turtle nesting is really an indicator of itself rather than system health. Juvenile sea turtle monitoring however might be a good indicator local ecological health (BUIS is piloting a program).

Exotic plants – Meeting participants felt the closed circles indicating sufficient monitoring for exotic plants was overstating the case and more monitoring was needed, especially in the USVI parks, but all parks mentioned need for improvement.

Visitor Use – BICY wanted to make sure that visitor use included ORV use as this is an important issue for their park.

Bob Sobzyak's method of reporting hydrology data for BICY was liked by the superintendents and it was recommended that SFCN explore this approach for other indicators.

Importance for each park
The meeting participants ranked the importance of each of the first 32 indicators for each park as High (H), Low (L), or not applicable (-).

Final Ranks
The final rankings are presented in the attached table.

Other issues
State of the Parks Reports
Park superintendents commented that they are receiving repeated requests for information for various types of "State of the Parks" reports such as the Watershed Condition Assessment. They asked if they could direct such requests to I & M to supply data. Matt agreed and said SFCN would be happy to collaborate.

Permits & Access
Matt requested that SFCN staff be dealt with as park staff for the purpose of working in the parks rather than having to apply for permits like non-NPS researchers. The superintendents agreed but emphasized that SFCN staff would have to go through the same in-house procedures that park staff did. Matt requested that this be put into writing and will draft an agreement/memo for the group to look at. Dan Kimball (EVER Superintendent) asked Matt to set up a meeting at EVER. Ron Clark recommended contacting Nancy about the South Florida Accessions Charter.

SFCN Vital Signs Ranking Meeting Agenda

Meeting purpose – To review network indicator ranking and achieve agreement on a prioritized list of Vital Sign indicators for the South Florida/Caribbean Network long-term monitoring program.

Meeting Objectives:

6.) **Provide update on network activities**
7.) **Provide overview of indicator development**
8.) **Review ranking results**
9.) **Develop and achieve agreement upon a prioritized list of Vital Signs Indicators**
10.) **Discuss how best to implement Vital Signs monitoring for selected indicators**

Tuesday – May 9, 2006

8:30-9:00 AM	**Coffee and time for informal introductions**
9:00-9:15 AM	**Opening remarks\Welcome from Superintendent Joel Tutein**
9:15-9:45 AM	**Overview of agenda & housekeeping issues**
	Indicator Development Process
	- **Overview of Vital Signs Program**
	- **Indicator Workshops**
	- **Ranking Process**
9:45-10:30 AM	**Indicator Ranking Review**
	Overall Ranks (Mgmt, Legal, Ecological, Feasibility)
10:30-10:45 AM	**Break**
10:45-11:00 AM	**Presentation: Coral Monitoring – Jeff Miller**
11:00-12:00 PM	**Indicator Ranking Review -Does ranking change with different queries? (S Fl Vs USVI; Internal/External; Combos)**
12:00-1:00 PM	**Lunch**
1:00-1:15 PM	**Presentation: GIS synthesis – Sasha Wright**
1:15-1:45 PM	**Participants review information and identify indicators to discuss**
1:45 – 2:00 PM	**Break**
2:00-2:15 PM	**Presentation: NOAA fish & mapping – Rob Waara**
2:15-3:00 PM	**Indicator Ranking – Discussion**
	- **Clarification on indicators & rankings**
	- **What's missing?**
	- **Is there anything missing from top 20? What should be shifted?**
3:00-3:15 PM	**Break**
3:15-4:00 PM	**Continue Discussion**
4:00-4:30 PM	**Day 1 Wrap-up**

Optional – Demonstration of coral monitoring at beach

Wednesday – May 10, 2006

8:30-9:00 AM	**Coffee**
9:00	**Presentation: LIDAR – Judd Patterson** **Review Day 1 and goals for Day 2** **Continue Discussion on Indicators**
10:30-10:45 AM	**Break**
10:45-11:00 AM	**Presentation: Water Quality – Kevin Whelan**
11:00-12:00 PM	**Continue Discussion on Indicators** **Agreement on prioritized list of indicators**
12:00-1:00 PM	**Lunch**
***12:30-1:00 PM**	**Alternative (invertebrate) Vital Signs selection project at the Mermaid Restaurant. All meeting participants are encouraged to join us.**
1:00-1:15 PM	**Presentation: Vegetation Mapping – Andrea Atkinson**
1:15-2:00 PM	**Overview of Phase 3 process** - **overview, outline, timeline** - **strategies/tools for making it all fit w/examples**
2:00-2:15 PM	**Break**

2:15-2:30 PM	**Presentation: Data management –Brian Witcher**
	Continue Phase 3 Process presentation
	- **data analysis & reporting w/examples**
	- **user friendly conceptual models**
	- **what we need from them**
	    o **review time**
	    o **permits**
	    o **cooperation on existing monitoring**
	
	Discussion on Phase 3 process
	Questions? Opportunities? Concerns? Needs (e.g. prioritizing issues to help GMP process)

4:00-4:30 PM	**Meeting wrap up and action items – Thank you**

****

Table 1. SFCN Vital Signs indicators sorted in priority order plus rating of importance by park and estimates of levels of existing monitoring estimated to be currently occuring for each indicator by park.

Importance to Park (park superintendants rated top 32 indicators): - = Not applicable to park; L = Low importance to park management; H = High importance to park management

Estimated Level of existing monitoring: ○ = No monitoring occuring but within indicator geographic scope; ◑ = Some monitoring occurring, but either protocol or sampling scope would need change; ● = Lots of monitoring occuring, little change presumed needed to level of effort, protocol, or scope

			Importance to Park							Estimated level of existing monitoring						
Original Rank	**Revised Priority Rank**	**Indicator**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**
1	**1**	Coral Communities	-	H	H	H	L	H	H		◑	◑	◑	○	○	◑
2	**2**	Exploited Fish Assemblage - Grouper, Snapper, (parrotfish, surgeonfish in USVI)- population structure, status, and trends	-	H	H	H	H	H	H		◑	◑	◑	◑	◑	◑
3	**3**	Hydrology = water stage, flow, timing, and duration.	H	H	L	L	H	H	L	●	●	○	○	●	○	○
4	**4**	Seagrass and other SAV cover and community composition	-	H	H	H	H	H	H		◑	○	◑	●	○	◑
5	**5**	Water Quality- Nutrients characteristics of the marine water bodies	-	H	L	H	H	H	H		●	○	◑	●	○	●
6	**6**	Invasive exotic plants	H	H	L	H	H	L	H	●	●	◑	◑	●	◑	◑
7	**7**	Freshwater Inputs to Estuaries	L	H	-	-	H	L	-	○	●			◑	○	
8	**8**	Marine Invertebrates - Rare, threatened, and endangered species - *Acropora, Diadema, Antipathes*	-	H	H	H	L	H	H		○	◑	○	○	○	◑
9	**9**	Shape, orientation, location, and coverage of vegetation community types	L	H	L	H	H	L	H	◑	◑	○	○	●	○	○
10	**10**	Wading birds - Regional South Florida - Systematic Reconnaissance Flights	H	-	-	-	H	-	-	●				●		
11	**11**	Spatial and Temporal Salinity Patterns	-	H	-	-	H	L	L		◑			◑	○	○
12	**12**	Surface Water Quality- physiochemical surface water characteristics at specific locations.	L	H	-	-	H	L	L	◑	○			●	○	○
13, 31	**13**	Exploited Inverts (Lobster, Conch, Crabs, Shrimp, Stone Crab, Blue Crab, Clams, Oysters, Sponges, Whelks)	-	H	L	H	H	L	H		◑	◑	◑	◑	◑	◑
14	**14**	Land Development inside/outside the park (within 5 mile radius for USVI parks, radius may be expanded to 75 miles in South Florida)	H	H	L	-	H	H	H	◑	◑	◑		◑	◑	◑
15	**15**	Marine Fish Communities - Coastal Shelf / Deep oceanic - Status, structure, trends	-	H	H	H	H	L	H		●	●	●	●	●	●
16	**16**	Colonial Nesting Birds (e.g. Least terns, pelicans, boobies, roseatte terns, egrets, storks, herons)	H	H	L	H	H	L	H	●	●	●	●	●	○	●
17	**17**	Invasive exotic fauna	H	L	L	L	H	L	H	○	◑	◑	◑	◑	○	○
18	**18**	Nutrient Loading and Sediment Loading	L	H	L	-	H	H	H	◑	●		○	●	○	◑

Table 1. SFCN Vital Signs indicators sorted in priority order plus rating of importance by park and estimates of levels of existing monitoring estimated to be currently occuring for each indicator by park.

Importance to Park (park superintendants rated top 32 indicators): - = Not applicable to park; L = Low importance to park management; H = High importance to park management

Estimated Level of existing monitoring: ○ = No monitoring occuring but within indicator geographic scope; ◑ = Some monitoring occurring, but either protocol or sampling scope would need change; ● = Lots of monitoring occuring, little change presumed needed to level of effort, protocol, or scope

			Importance to Park							Estimated level of existing monitoring						
Original Rank	**Revised Priority Rank**	**Indicator**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**
19	**19**	Visitor Use (Both commercial and individual/personal use)	**H**	**H**	**H**	**H**	**H**	**H**	**H**	◑	◑	◑	◑	◑	○	◑
20	**20**	Early detection, status, and trends of non-indigenous aquatic species.	L	L	-	-	**H**	L	L	○	○			◑	○	○
21,36,42,46,50	**21**	Marine Fish Communities - Bays/Mangroves - Status, structure, trends	L	**H**	-	**H**	**H**	L	**H**	○	◑		○	◑	○	○
~~**21**~~		~~Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Visual Assessment~~								~~○~~	~~◑~~		~~○~~	~~◑~~	~~○~~	~~○~~
22, 43	**22**	Location of critical ecotones - field plots/transects	**H**	**H**	L	**H**	**H**	L	**H**	◑	○	◑	○	◑	◑	◑
23	**23**	Periphyton	**H**	L	-	-	**H**	-	-	○	○			●		
24	**24**	Freshwater fish and large macro-invertebrates in wet prairies and marshes	**H**	-	-	-	**H**	-	L	◑				●		○
25	**25**	Contaminants in water column, organisms, and sediments.	**H**	**H**	L	L	**H**	**H**	**H**	◑	◑	○	○	◑	○	○
26	**26**	Long-term, within-community vegetation shifts using permanent plots	L	L	**H**	L	**H**	L	**H**	◑	○	○	○	◑	○	●
27	**27**	Sea Turtles	-	**H**	**H**	**H**	L	L	**H**		◑	●	●	○	○	●
28	**28**	American crocodile (*Crocodylus acutus*)	L	**H**	-	L	**H**	-	-	○	●		○	●		
29	**29**	American alligator (*Alligator mississippiensis*)	**H**	-	-	-	**H**	-	-	●				●		
30	**30**	Benthic community spatial & temporal changes in extent and distribution -remote sensing	-	**H**	**H**	**H**	**H**	**H**	**H**		◑	◑	◑	◑	◑	◑
~~**31**~~		~~Spiny lobster - population structure, status, and trends~~									~~◑~~	~~◑~~	~~◑~~	~~○~~	~~○~~	~~○~~
40	**31**	Land Birds - residential and migratory	L	**H**	**H**	**H**	**H**	**H**	**H**	○	◑	◑	○	○	○	◑
37,61	**32**	Amphibians - South Florida & USVI	**H**	L	-	-	**H**	L	**H**	○	○			○	○	○
32	**33**	Ecotone shifts along wetland boundaries - Mangrove to marsh to cypress- Aerial photography								○	○			◑		
33	**34**	Sediment elevation in mangroves and mud banks (Fl Bay) Salt Ponds (USVI) and Mangroves fringes								○	○	○		●	○	○

Table 1. SFCN Vital Signs indicators sorted in priority order plus rating of importance by park and estimates of levels of existing monitoring estimated to be currently occuring for each indicator by park.

Importance to Park (park superintendants rated top 32 indicators): - = Not applicable to park; L = Low importance to park management; H = High importance to park management

Estimated Level of existing monitoring: ○ = No monitoring occuring but within indicator geographic scope; ◑ = Some monitoring occurring, but either protocol or sampling scope would need change; ● = Lots of monitoring occuring, little change presumed needed to level of effort, protocol, or scope

			Importance to Park							Estimated level of existing monitoring						
Original Rank	**Revised Priority Rank**	**Indicator**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**
34	**35**	Marine Vertebrates - Rare, threatened, and endangered species - Crocodiles, Dolphin, Manatee, Sea Turtles, Protected marine mammals.								◑	◑	◑	◑	◑	○	◑
35	**36**	Physical drivers of mangrove-marsh ecotone									◑			◑		
~~36~~		~~Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Seining~~								~~○~~	~~◑~~		~~○~~	~~◑~~	~~○~~	~~○~~
~~37~~		~~Amphibians - South Florida~~								~~○~~	~~○~~			~~○~~	~~○~~	~~○~~
38	**37**	Fire Return Interval Departure								◑				◑		
39	**38**	Goliath Grouper (Red Hind in VI) - population structure, status, and trends									◑	○	◑	●	○	◑
41	**39**	Critically Imperiled and Rare Plants:								○	◑	○	○	◑	○	○
~~42~~		~~Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Throw trap~~								~~○~~	~~◑~~	~~○~~	~~○~~	~~◑~~	~~○~~	~~○~~
~~43~~		~~Location of Hammock-Pineland ecotone - field plots/transects~~								~~○~~				~~○~~		
44	**40**	Pink Shrimp population structure, status, and trends									●	○	○	●	○	○
45	**41**	Aquatic invertebrates in wet prairies and marshes								◑	○			●		
~~46~~		~~Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Trawling~~								~~○~~	~~◑~~		~~○~~	~~◑~~		
47	**42**	Land birds - Mangrove - population abundance and distribution								○	○	○	○	○	○	○
48	**43**	Bonnethead, Lemon, Bull, Nurse Sharks - population structure, status, and trends									◑		●	●		
49	**44**	Florida panther								●				●		
~~50~~		~~Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Other trapping~~								~~○~~	~~◑~~	~~○~~	~~○~~	~~◑~~	~~○~~	~~○~~
51	**45**	Gray Snapper (Schoolmaster in VI)- population structure, status, & trends									●	○	◑	◑	○	◑
52	**46**	Position and Spatial Extent of Mud Banks, Buttonwood Embankment and Berms								○	○			◑		

Table 1. SFCN Vital Signs indicators sorted in priority order plus rating of importance by park and estimates of levels of existing monitoring estimated to be currently occuring for each indicator by park.

Importance to Park (park superintendants rated top 32 indicators): - = Not applicable to park; L = Low importance to park management; H = High importance to park management

Estimated Level of existing monitoring: ○ = No monitoring occuring but within indicator geographic scope; ◑ = Some monitoring occurring, but either protocol or sampling scope would need change; ● = Lots of monitoring occuring, little change presumed needed to level of effort, protocol, or scope

			Importance to Park							Estimated level of existing monitoring						
Original Rank	**Revised Priority Rank**	**Indicator**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**	**BICY**	**BISC**	**BUIS**	**DRTO**	**EVER**	**SARI**	**VIIS**
53	**47**	Oyster population structure, status, and trends									○			○		
54	**48**	Spotted Sea Trout - population structure, status, and trends									◑		◑	◑		
55	**49**	Landbirds - Pine Rockland - population abundance and distribution.								◑				◑		
56	**50**	Phytoplankton composition and biomass									◑		◑	◑		
57	**51**	Spatial and temporal changes in extent and distribution of substrate type (marl vs. peat).												○		
58	**52**	Snook - population structure, status, and trends								○	●		◑	●		
59	**53**	Infaunal benthic community structure and abundance for animals									○			○		
60	**54**	Pig Frog (*Rana grylio*)								○	○			○		
~~**61**~~		~~Amphibians - USVI~~													~~○~~	~~○~~
62	**55**	Landbirds-Cavity-nesting pine rockland birds - Demographics (Fecundity and Survival)								◑				◑		
63	**56**	Sawfish- population structure, status, and trends									○		○	◑		
64	**57**	Reptiles - USVI										○			○	○
65	**58**	Long-term sediment elevation changes in cypress strands and domes								○				○		
66	**59**	Florida Box Turtle (*Terrapene Carolina bauri)*								○	○			○		
67	**60**	Bats - USVI										○			○	○
68	**61**	Butterflies								○	◑	○	○	◑	○	○
69	**62**	Island Insects									○	○	○		○	○

Table 8. Indicators sorted by General Category, Sub-Category, then by rank order from Table 1. Top 20 highlighted

General Category	Sub-Category	Indicator	Table 1 Order
Geology & Soils		Sediment elevation in mangroves and mud banks (Fl Bay) Salt Ponds (USVI) and Mangroves fringes	**33**
		Position and Spatial Extent of Mud Banks, Buttonwood Embankment and Berms	**52**
		Spatial and temporal changes in extent and distribution of substrate type (marl vs. peat).	**57**
		Long-term sediment elevation changes in cypress strands and domes	**65**
Water		Hydrology = water stage, flow, timing, and duration.	**3**
		Water Quality- Nutrients characteristics of the marine water bodies	**5**
		Freshwater Inputs to Estuaries	**7**
		Spatial and Temporal Salinity Patterns	**11**
		Surface Water Quality- physiochemical surface water characteristics at specific locations.	**12**
		Nutrient Loading and Sediment Loading	**18**
		Contaminants in water column, organisms, and sediments.	**25**
		Phytoplankton composition and biomass	**56**
Invasive species		Invasive exotic plants	**6**
		Invasive exotic fauna	**17**
		Early detection, status, and trends of non-indigenous aquatic species.	**20**
Bays & Marine	Benthic mapping	Benthic community spatial & temporal changes in extent and distribution -remote sensing	**30**
	SAV	Seagrass and other SAV cover and community composition	**4**
	Fish	Exploited Fish Assemblage - Grouper, Snapper, (parrotfish, surgeonfish in USVI)- population structure, status, and trends	**2**
		Marine Fish Communities - Coastal Shelf / Deep oceanic - Status, structure, trends	**15**
		Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Visual Assessment	**21**
		Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Seining	**36**
		Goliath Grouper (Red Hind in VI) - population structure, status, and trends	**39**
		Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Throw trap	**42**
		Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Trawling	**46**
		Bonnethead, Lemon, Bull, Nurse Sharks - population structure, status, and trends	**48**
		Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Other trapping	**50**
		Gray Snapper (Schoolmaster in VI)- population structure, status, & trends	**51**
		Spotted Sea Trout - population structure, status, and trends	**54**
		Snook - population structure, status, and trends	**58**
		Sawfish- population structure, status, and trends	**63**
	Invertebrates	Coral Communities	**1**
		Marine Invertebrates - Rare, threatened, and endangered species - Acropora, Diadema, Antipathes	**8**
		Exploited Inverts (Lobster, Conch, Crabs, Shrimp, Stone Crab, Blue Crab, Clams, Oysters, Sponges, Welks)	**13**
		Spiny Lobster - population structure, status, and trends	**31**
		Pink Shrimp population structure, status, and trends	**44**
		Oyster population structure, status, and trends	**53**
		Infaunal benthic community structure and abundance for animals	**59**
	Large Marine Vertebrates (mammals, reptiles)	Sea Turtles	**27**
		American crocodile (Crocodylus acutus)	**28**
		Marine Vertebrates - Rare, threatened, and endangered species - Crocodiles, Dolphin, Manatee, Sea Turtles, Protected marine mammals.	**34**

General Category	Sub-Category	Indicator	Table 1 Order
Wetlands & Uplands	Fire	Fire Return Interval Departure	**38**
	Vegetation	Shape, orientation, location, and coverage of vegetation community types	**9**
		Location of critical ecotones - field plots/transects	**22**
		Periphyton	**23**
		Long-term, within-community vegetation shifts using permanent plots	**26**
		Ecotone shifts along wetland boundaries - Mangrove to marsh to cypress- Aerial photography	**32**
		Physical drivers of mangrove-marsh ecotone	**35**
		Critically Imperiled and Rare Plants:	**41**
		Location of Hammock-Pineland ecotone - field plots/transects	**43**
	Fish	Freshwater fish and large macro-invertebrates in wet prairies and marshes	**24**
	Invertebrates	Aquatic invertebrates in wet prairies and marshes	**45**
		Butterflies	**68**
		Island Insects	**69**
	Herpetofauna & Mammals	American alligator (Alligator mississippiensis)	**29**
		Amphibians - South Florida	**37**
		Florida panther	**49**
		Pig Frog (Rana grylio)	**60**
		Amphibians - USVI	**61**
		Reptiles - USVI	**64**
		Florida Box Turtle, Terrapene Carolina bauri	**66**
		Bats - USVI	**67**
	Birds	Wading birds - Regional South Florida - Systematic Reconnaissance Flights	**10**
		Colonial Nesting Birds (e.g. Least terns, pelicans, boobies, roseatte terns, egrets, storks, herons)	**16**
		Land Birds - residential and migratory	**40**
		Land birds - Mangrove - population abundance and distribution	**47**
		Landbirds - Pine Rockland - population abundance and distribution.	**55**
		Landbirds-Cavity-nesting pine rockland birds - Demographics (Fecundity and Survival)	**62**
Human Use		Land Development inside/outside the park (within 5 mile radius for USVI parks, radius may be expanded to 75 miles in South Florida)	**14**
		Visitor Use (Both commercial and individual/personal use)	**19**

This page intentionally left blank

Appendix O-6

SFCN Indicator Worksheets

APPENDIX O.6 SFCN Indicator Worksheets

Table of Contents

Wetlands and Uplands

Human Use

A. *Position and Spatial Extent of Mud Banks, Buttonwood Embankment and Berms*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Position and Spatial Extent of Mud Banks, Buttonwood Embankment and Berms
Monitoring Question(s):	How do berms, embankments and mud banks influence circulation and water flows and how will they respond to everglades restoration and climate changes?
Justification:	Berms, embankments, and mud banks in Florida and Biscayne Bays have substantial influence on water exchange and the general circulation patterns between the near shore estuaries and oceanic water bodies. Monitoring the position and spatial extent of these structures is critical to understand the connectivity of the water bodies for processes like: larval recruitment, export of dissolved organic matter, salinity, nutrient patterns, etc. Everglades restoration, water delivery, large storm events, and sea level rise could all affect these ecosystem structures. Long-term resource management will need to understand the change in position and spatial extent to properly understand changes within the system.
Metric:	- Location and spatial extent (historically and at present) - Change in location and extent - Elevation (see Sediment elevation in mangroves and mud banks (Fl Bay) Salt Ponds (USVI) and Mangroves fringes)
Method:	- Historic maps, charts, and air photos - Recent air photos, bathy mapping, GIS analysis
Frequency:	Every 2-3 years
Timing:	Airphotos with no clouds
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks Multiple NPS units, FWS units, and state/local parks have SETS- Those are in multiple biogeographic regions.
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Site specific Processes affecting elevation occur over multiple scales.
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks
Basic Assumptions:	Physical features such as mudbanks both affect water movement and will themselves be affected by CERP (QQTD) and climate.
Research Needs:	Understanding natural rates of change
Management Goal:	No net change (?) What does management do if you discover that basins are filling in naturally?
Threshold Target:	Insufficient knowledge
Response:	See Management goals above

Constraints: Better understanding of mudbank dynamics as related to upstream inflows

Status: All of the above. An excellent map of historic bathymetry for Fl Bay has been compiled (contact Bob Halley)
The FATHOM hydrology model uses the best available bathymetry

Have "good" data for Buttonwood embankment and Fl Bay and BISC
NEED data for 10,000 Islands from Everglades City to NW Cape Sable

Estimated Cost: - 150K- bathymetric survey of 10,000 Islands
- 200K Resurveys with air photos and GIS analysis

References: Hal Wanless (UM), Bob Halley (USGS), Kim Yates (USGS St. Pete), Bill Buttle, Jim Fourqurean (FIU), Mike Robblee (USGS @ EVER)- last three worked on FATHOM model

B. *Sediment elevation in mangroves and mud banks (Fl Bay) Salt Ponds (USVI) and Mangroves fringes*

Which conceptual model(s) is this indicator linked to?

☑ Island Interior ☑ Mangroves ☑ Florida Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Sediment elevation in mangroves and mud banks (Fl Bay) Salt Ponds (USVI) and Mangroves fringes
Monitoring Question(s):	How does sediment dynamics (accretion, subsidence and erosion) in mangroves, mud-banks, salt ponds respond to: 1) hydrology (Quality, quantity, timing and duration), 2) Sea-level, 3) Storms / hurricanes, and 4) upland erosion.
Justification:	Sediment dynamics (the build up or loss of) is a basic process that can have far reaching impacts on the ecosystem. It is especially important in mangroves, mud-banks, and salt ponds. In South Florida, hydrology, sea-level rise and storms have been found to affect mangrove and mud bank sediment elevation. Everglades restoration of regional hydrology is expected to impact this issue. In the U.S. Virgin Islands, sediment filling of ephemeral guts and salt ponds from upland development is an important issue.
Metric:	- Measure relative elevation, elevations change, accretion/erosion at "sentinel" sites.
Method:	- Use Surface Elevation Tables (SETs) and marker horizons. See Whelan et al (2005), Estuaries 28(6) and References there in (esp. Cahoon et al 2002). - Do in conjunction with vegetation monitoring and surface and ground water monitoring.
Frequency:	quarterly- mangroves at first, maybe able to drop back to biannual (Wet and Dry) - sample after storm events
Timing:	Need to be able to respond rapidly to an "event"- a hurricane, fire, and flood.
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks Multiple NPS units, FWS units, and state/local parks have SETS- Those are in multiple biogeographic regions.
Scale of Operation:	Regional (incl. areas outside parks, Multiple Parks, Park-wide, Site Specific, Processes affecting elevation occur over multiple scales
Scale of Analysis:	Multiple parks, Site Specific
Basic Assumptions:	Sediment Elevation Table (SET) pipe is a benchmark and does not move (Surveys of the SET pipes can be done to make sure this is the case) Other assumptions from the Scale of Process above
Research Needs:	- Role of ground-water (see Whelan et al 2005) - Nutrient impacts role of ground-water (see Whelan et al 2005) - Nutrient impacts on below ground production - More work on role of storms- they can add sediment or kill vegetation leading to sediment loss ("peat collapse") - Role of fire along the mangrove- marsh ecotone
Management Goal:	Trend support management goals for no human influences on trends (upwards or downwards depending on system) -
Threshold	Slope is zero or positive +/- 10-20%

Target: Relate ground elevation to lowest seaward berm height (VIIS)
Accumulation of sediment in Salt Ponds and guts tied to natural process (and rates) and not to anthropogenic run off.

Response: Replant mangroves after disturbance
If not "keeping pace"- add phosphorous
Upland sediment reduction measures for erosion runoff into salt ponds

Constraints: - Known to work very well in coastal (tidal) wetlands and mud-banks (Fl Bay)
- Has not been used in US VI

Status: Ongoing:
- SETS are widely used. 3 networks are present in ENP. TJ Smith has sites along Shark and Lostmans. R. Halley has SETS on mud-banks in Fl bay (5 sites). F. Sklar (2) has SETS in the Taylor Sough/ C 111 area.
- Smith is funded starting Feb 2006 by Coe/Recover

Sediment dynamics are a Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan (MAP) indicator.

Estimated Cost: For SETs, marker horizons, hydrology sampling (surface and ground water) and vegetation- ALL at the site ~25K/year

References: For mangroves and Fl. Bay mudbanks see Bob Halley
USGS and MIT looking at sedimentation inputs into salt ponds (in 1970's).

C. *Spatial and temporal changes in extent and distribution of substrate type (marl vs. peat).*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes

Parks where monitoring would be conducted

☑ EVER

Indicator:	Spatial and temporal changes in extent and distribution of substrate type (marl vs. peat).
Monitoring Question(s):	What is the status of substrate types at landscape scales over time? Are abnormal changes occurring?
Justification:	Many of the biogeochemical process that are critical in nutrient cycling and sediment generations in the fresh water Everglades is dependent on substrate type (marl vs. peat). Understanding the regional pattern of peat and marl and changes between these substrates is critical to interpret other process occurring with in the fresh water marshes. The extended hydroperiods proposed through Everglade's restoration may promote conversion from marl to peat substrates.
Metric:	Changes in large-scale patterns and extent of associated vegetation communities determined from aerial photography. Changes in surficial substrate physiochemical characteristics such as organic matter/ash content and depth and duration of flocculent detrital material determined from soil samples taken along predetermined transects.
Method:	Using vegetation maps and aerial photography, sites for soil transects will be determined and revisited at predetermined intervals.
Frequency:	Every 5 years, quarterly transect sampling during first year to determine possible rates of change then determine future visits.
Timing:	Not season specific, as determined from evaluation of vegetation maps and aerial photography. Quarterly (seasonal) transect sampling during first year to determine possible rates of change then determine future visits.
Scale of Collection:	Multiple Parks, Site Specific: after baseline verified, frequency determined
Scale of Operation:	Regional (incl. areas outside parks), Along transitional gradients (peat to marl)
Scale of Analysis:	Park-wide, Site specific along transitional gradients.
Basic Assumptions:	The underlying assumption is that hydrology affects the balance between organic matter production and respiration with longer hydroperiods leading to increasingly organic systems. Therefore changes in hydrologic conditions are important links to this process.
Research Needs:	Understand sources of change (baseline conditions) in substrate types.
Management Goal:	To maintain a healthy balance between peat and marl substrate systems.
Threshold Target:	Insufficient Knowledge

Response:	Modification of water management regime to hydroperiods that maintain desired substrate balance.
Constraints:	Should link extent and changes to alterations/variation in hydroperiod including depth and duration of inundation.
Status:	Course-scale vegetation mapping currently underway by SFWMD and NPS.

Estimated Cost:

References:

D. *Long-term sediment elevation changes in cypress strands and domes*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Long-term sediment elevation changes in cypress strands and domes
Monitoring Question(s):	Does soil surface elevation change in cypress strands and domes over time? What are the processes in the soil profile that dictate these changes?
Justification:	The change in soil surface elevation in cypress strand and domes dictate the hydroperiod which drives the cypress community dynamics (seedling recruitment, survival, decomposition). Long-term resource management of the forest wetlands requires an understanding of how the soil surface elevation changes in response to seasonal wetting, shrink-swell of soils, and fire.
Metric:	Documenting elevation change and processes associated with elevation change in cypress strands and domes of south Florida. This must include actual elevation change as well as subsidence, vertical accretion, and erosion, and should include at least some idea of deep vs. shallow subsidence/elevation change.
Method:	Establish a network of deep and shallow sedimentation-elevation tables (SET) for a statistically valid (i.e., using power analysis from past variation estimates) number of representative locations in cypress strands and domes in BICY and EVER. Perhaps include external locations within the BICY and EVER region?
Frequency:	Every 5-10 years (approximate interval), Quarterly - must be a sampling design that is sensitive to the seasonality of south Florida.
Timing:	Easiest to measure SETs during low-water periods; however, all periods should be considered. Vertical accretion sampling is also difficult under water.
Scale of Collection:	Regional (incl. areas outside parks) Note: Including refuge lands (e.g., Florida Panther NWR) May be good in order to include a larger assessment region along multiple Tamiami Trail crossings.
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Elevational processes associated with SET location are indicative of the larger community and can be linked appropriately to hydrological changes, fire, and shrink-swell events.
Research Needs:	Determine how elevation changes in south Florida cypress swamps are affected by seasonal wetting, anthropogenic water manipulations, and other landscape drivers (e.g., fire).
Management Goal:	Use management tools to the extent possible to maintain soil elevation as static as possible. This metric will provide an indication of soil elevation loss due to organic matter oxidation or combustion, as well as due to mineral sedimentation processes (directly or indirectly). This assumes that much of the cypress zone is currently at an elevation state that is acceptable as a target condition. SETs will also assist with defining this target condition.
Threshold Target:	Small changes in elevation over time become less of a problem as the time interval of monitoring increases. Consult Donald Cahoon and Phillippe Hensel (USGS-Patuxant) for specifics and long-

term statistical analyses of these ideas. For instance, a 2 mm elevation change over 1 year becomes 20 mm over 10 years. If the first trend is not real, the longer term trend will not be found.

Response: Increase water flow to limit soil oxidation processes or prolong the fire return interval to the system. On the flip side, these data may support a shorter fire return interval if elevation is unaffected by repetitive fires.

Constraints: Standardizing sampling techniques over time with personnel turnover and budget changes. This is especially important for SET measurements. Again, consult Donald Cahoon, Philippe Hensel, or Kevin Whelan about potentials for sample error with personnel changes associated with SET readings.

Status: SETs are currently being used in several south Florida mangrove areas. None, to my knowledge, are being used in cypress swamps.

Estimated Cost: SET tables and sampling equipment can be purchased for about $3000 per device, but with pipes and supplies an estimate of $5000 for an entire set-up can be assumed. After the initial set-up, the per-SET price increases considerably. My guess is that $40-50K, as a one-time allocation would be sufficient for installing a fairly robust network over BICY, EVER, or Florida Panther NWR within the cypress swamps. This estimate excludes personnel costs and costs associated with re-measurement (probably $8-10K per annum for the latter??).

References: Kevin Whelan is an excellent source for how this type of sampling might be accomplished. Don Cahoon, Phillippe Hensel, and Jim Lynch (USGS-Patuxant) would be good sources for exact costs associated with this sort of monitoring.

E. *Hydrology = water stage, flow, timing, and duration.*

Which conceptual model(s) is this indicator linked to?

- [x] Freshwater Wet Prairies and Marshes
- [x] Forest Uplands and Wetlands
- [x] Island Interior
- [x] Mangroves
- [x] Florida Bay
- [x] Biscayne Bay

Parks where monitoring would be conducted

- [x] BICY
- [x] BISC
- [x] DRTO
- [x] EVER
- [x] SARI
- [x] VIIS

Indicator:	Hydrology = water stage, flow, timing, and duration.
Monitoring Question(s):	What is the hydrology (quantity, timing, duration, flow) of the current system?
Justification:	Hydrology is an important driver in most ecosystems. Understanding the quantity, timing, duration, and flow of the hydrology allows a basic comprehension of how this major process affects the ecosystem. Additionally, a general understanding of hydrology is a necessary covariate to interpret other indicators. Everglades restoration is fundamentally expected to affect South Florida regional hydrology.
Metric:	Water quantity, depth, timing, and duration = hydroperiod (stage/depth of water at a specific location) - preemptive with management as additional trigger
Method:	Continuous measurement of stage at appropriate sites upstream to and in appropriate locations. Periodic measures of water velocity in concert with stage.
Frequency:	Continuous
Timing:	Continuous
Scale of Collection:	Regional (incl. areas outside parks), Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Site Specific-During releases upstream
Scale of Analysis:	Regional (incl. areas outside parks), Site Specific-During releases upstream
Basic Assumptions:	Loadings can be calculated using stage/flow/concentration.
Research Needs:	Determine flow volume related to stage and flow velocity at specific points in EVER, VIIS, etc.
Management Goal:	Appropriate stages for the health of the wetland, meeting water quality criteria for wetlands (upstream and receiving bodies). Reduce adverse nutrient flow into FL Bay. Reduce nutrient flow into salt ponds and receiving water bodies.
Threshold Target:	Insufficient knowledge - depends upon what desired characteristics are being controlled for (ridge/slough patterning, SAV, periphyton, nutrient concentrations, flow rates, etc.)
Response:	Work with Water Management Districts to modify water releases, water redirection, and possibly implement buffer wetlands etc.
Constraints:	Dependent on continuous availability of upstream stage data, rainfall volume data, etc.
Status:	Contingent also on Surface Water Quality monitoring effort.

Hydrology monitoring is a major focus in Comprehensive Everglades Restoration Program (CERP) Monitoring and Assessment Plan (MAP).

Estimated Cost: Stage gauges for EVER-$1K per site?

References:

F. *Spatial and Temporal Salinity Patterns*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Spatial and Temporal Salinity Patterns
Monitoring Question(s):	What is the spatial and temporal distribution of physical characteristics (Salinity, Conductivity, pH, Dissolved Oxygen, Temperature, Redox) throughout the marine water bodies (Coastal Embankments, Central Bay, "open" bay).
Justification:	Physical characteristics of marine water bodies establish the environmental constraints within which other organisms must survive. Understanding the spatial and temporal distribution of the physical characteristics within marine water bodies allows more complete interpretation of other indicators. For example, historically salinity monitoring has been correlated with benthic community monitoring, productivity analysis, fish and other organismal sampling.
Metric:	Salinity, Temp, Depth
Method:	Salinity mapping (shipboard, e.g. NOAA/AOML, SFWMD) Use instrumentation to continuously measure salinity. QAQC procedures to calibrate and post calibrate meters. Determine corrections that would be applied for instrumental deterioration. See USACE/ BISC project/ CERP
Frequency:	Continuous- potential for selected parameters Supplemented "grab" samples, seasonal and event mapping.
Timing:	All Year
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Salinity is a controlling factor in the survival, distribution, health, and patterning on the water column, biotic community and in the benthic community
Research Needs:	Palioecologic studies to determine historical salinities Salinity tolerance and requirements of various mangrove fish or fish communities as well as benthic communities. Effects of salinity in mangrove communities. Effects of High Salinity discharge from RO water plants into near shore Bay.
Management Goal:	Salinity conditions to support historic communities At minimum support productive diverse communities
Threshold Target:	Use the following: CERP, BBCW, C111 Southeast Estuaries Performance Measures (CERP, RECOVER AT- MAP; ET FBFKFS). Minimize rapid decreases in salinity
Response:	Review and recommendations/ DOI to water managers to improve water flow and distribution

Constraints:	Parks have very little control over inflows, salinity is subject to water availability and distribution which is a highly political process
Status:	- USACE/ BISC- Continuous/ ongoing - DERM/ SFWMD- Salinity profiles, NE Fl Bay Embankments, BISC Bay- Monthly- ongoing - FIU/SFWMD- Monthly grab samples BISC and Fl Bay
Estimated Cost:	
References:	Sarah Bellmund (BISC), Joe Boyer (FIU), Joe Serafy (NOAA), Rick Alleman (SFWMD), Susan Markley (DERM), Chris Crawford, Viletta Mayor (DPNR)

G. *Freshwater Inputs to Estuaries*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER ☑ SARI

Indicator:	Freshwater Inputs to Estuaries
Monitoring Question(s):	What are the spatial and temporal patterns of freshwater input (surface, groundwater and atmospheric) to estuaries?
Justification:	Freshwater input, coupled with hydrodynamics and evaporation, determines spatial and temporal salinity patterns. Freshwater input is a major estuarine ecosystem driver. Anthropogenic alteration of freshwater input is a major estuarine ecosystem stressor, likely the most important for Biscayne Bay, Florida Bay, and Gulf coast estuarine ecosystems. Specifically, this indicator concentrates effort at tracking the hydrological inputs from the territorial system into the near shore marine environments making this a more precise indicator than the general hydrology indicator (Hydrology = water stage, flow, timing, and duration).
Metric:	Surface water inflow volume: flow rate, water level or stage Ground water flow volume (if practical) Precipitation (rainfall).
Method:	Standard surface water and precipitation collection methodology currently being used in EVER and BICY, and elsewhere by SFWMD and USGS. Standard methods for groundwater flow measurements (Consult groundwater hydrologists.)
Frequency:	Continuous
Timing:	Year round
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Multiple Parks
Basic Assumptions:	
Research Needs:	Groundwater monitoring and modeling development. Integrated surface, groundwater, atmospheric water budget model. Evaporation/transpiration (ET) measurements were needed for water budget determination and

	modeling.
Management Goal:	EVER, BISC, BICY (?) mission/strategic goals and CERP goals and objectives regarding restoring and maintaining more natural freshwater inflows to, salinity patterns in, and ecological "health" of estuarine ecosystems.
Threshold Target:	General targets in park mission/strategic goals. CERP salinity targets.
Response:	Comprehensive Everglades Restoration Plan (CERP), Combined Structure Operation Plan (CSOP), has specific sections addressing this concern.
Constraints:	Practicality of groundwater flow monitoring.
Status:	Surface water and precipitation monitoring on-going for much of Florida Bay. Water level/stage continuous monitoring instruments being installed in mangrove zone lakes (West, Seven Palms, Lungs). Need flow meter in Alligator Creek. Much of EVER Gulf coast estuaries have surface water and precipitation monitoring; consult EVER Physical Branch for additional needs. Few, if any, groundwater flow monitoring stations. A complete assessment is needed.
Estimated Cost:	
References:	EVER Physical Branch scientists; local USGS hydrologists and coastal scientists; SFWMD scientists.

H. *Water Quality- Nutrients characteristics of the marine water bodies*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Water Quality- Nutrients characteristics of the marine water bodies
Monitoring Question(s):	What is the spatial and temporal distribution of nutrients characteristics throughout the water bodies (i.e.. Coastal Embankments, Central Bay, "open" bay, Coral Bay).
Justification:	Nutrients within the marine ecosystem drive primary production and when unbalanced can have deleterious effects on the marine ecosystem. Understanding the spatial and temporal distribution of nutrients within the marine water bodies allows more complete interpretation to other indicators. Nutrients can change due to upstream/upland development, agricultural inputs, malfunctioning septic systems, boat discharges, atmospheric deposition, as well as internal cycling.
Metric:	Dissolved Inorganic Nitrogen (DIN) Dissolved Inorganic Phosphorous (DIP) Dissolved ammonia (NH4) Dissolved Organic Material (DOM) Dissolved Organic Carbon (DOC) Dissolved Organic Nitrogen (DON) Total Nitrogen (TN) Soluble Reactive Phosphorous (SRP) Total Nitrates (NO2 + NO3) Total Phosphorous (TP) Total suspended solids (TSS) Turbidity SECCHI Photosynthetically active radiation

	Fecal coliform Escherichia coli
Method:	- EMAP - Existing NPS and Territorial SOPS. - Grab sampling @ consistent depth (e.g.. 1m depth) utilizing EPA/SM analysis - Continuous measures (e.g.. SARI Crews Station, NOAA cruises) -limited parameter suite? - Utilizing historic sampling stations (DERM/ FIU) or establish protocol for network
Frequency:	Monthly, Event specific (high/low flow events- e.g.. tropical systems/ drought)
Timing:	All Year
Scale of Collection:	Regional (incl. areas outside parks), Site Specific: nearshore gradients/ Fl Bay emphasized
Scale of Operation:	Regional (incl. areas outside parks), Park-wide: BISC, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Park-wide, Site Specific: meter square to 10-100 hectares
Basic Assumptions:	- Circulation/ current patterns can result in localized effects of nutrient inputs, as well as distribute inputs throughout the water body
Research Needs:	Synergistic effects of dissolved organic and inorganic (broad scope nutrients) on primary production (eutrophication) Bioavailability/ decomposition of Dissolved Organic Matter Water quality model development Internal cycling rates (denitrification, N2 fixation)
Management Goal:	Appropriate levels and ratios to support primary productivity of SAV and phytoplankton, while limiting eutrophication and algal blooms
Threshold Target:	Meet all local, state, and federal water quality standards and criteria. Consider P:N ratios relative to "redfield ratio" - Specific dissolved/ total/ inorganic/ organic nitrogen targets - Light sufficient to sustain Benthic Habitat
Response:	Feasibility of upstream control? Review/ evaluation of "operations"/ flow patterns
Constraints:	- Limited control of inputs from upstream - Balance between needed water volume/ flow and water quality/ nutrient loading - Station matrix representation of site/ park/ regional scales
Status:	- SFWMD/ DERM- BISC bay/ Miami-Dade Co. canals (monthly grab sample) - SFWMD EVER WQ monitoring in eastern (general) EVER - SFWMD/FIU Biscayne Bay/ Fl Bay- Fl Bay month grab - NOAA Biscayne Bay/ Fl Bay "continuous" measure monthly cruises - Utilize/ augment existing programs
Estimated Cost:	
References:	David Rudnick (SFWMD), Trisha Stone (SFWMD), Susan Markley (DERM), Joe Boyer (FIU), Peter Ortner (NOAA)

I. *Nutrient Loading and Sediment Loading*

Which conceptual model(s) is this indicator linked to?

☑ Island Interior ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep

Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Nutrient Loading and Sediment Loading
Monitoring Question(s):	What is the nutrient loading and sediment loading to the estuary from all sources? What is the distribution of loading (location of load sources) along the coast? What is sediment loading to the guts and standing ephemeral pools at St. John only?
Justification:	This indicator builds on calculations from the "Surface Water Quality- physiochemical surface water characteristics at specific locations" and the "Hydrology = water stage, flow, timing, and duration", with the goal being calculations of nutrient and sediment loads for specific areas.
Metric:	- Discharge measures (flow) from major inputs (sloughs/ canals), surface, ground, overland - Associated concentration of nutrients for flow. Dissolved Inorganic Nitrogen (DIN) Dissolved Inorganic Phosphorous (DIP) Dissolved ammonia (NH4) Dissolved Organic Material (DOM) Dissolved Organic Carbon (DOC) Dissolved Organic Nitrogen (DON) Total Nitrogen (TN) Soluble Reactive Phosphorous (SRP) Total Nitrates (NO2 + NO3) Total Phosphorous (TP) Total suspended solids (TSS) Turbidity SECCHI Photosynthetically active radiation - Other nutrient sources and sinks (estimate atmospheric, oceanic, internal)
Method:	- Flow weighted WQ samples (nutrients) to capture short term (first flush) and longer period flow characteristics - Flow measures in a time step sufficient to characterize short and long-term flows - Atmospheric (dry and wet fall) - Offshore/ onshore - Groundwater estimates (may need models) - Knowledge of internal cycling - Guts in St. John, Inputs to SARI
Frequency:	Continuous- for overland/ creek/ discharge canal, Event based- sufficient to characterize varied flow regimes that occur "normally" and during events.
Timing:	Year
Scale of Collection:	Regional (incl. areas outside parks), Site Specific: Point sources (e.g.. Rivers, canals)
Scale of Operation:	Regional (incl. areas outside parks), Park-wide, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Park-wide, Site Specific
Basic Assumptions:	Loads at samples points are characteristic of major nutrient inputs, or minimally can be utilized to establish a relationship for "input" locations and loads.
Research Needs:	Modeling of transport and flux Waterbody specific nutrient response, rate, and transport
Management Goal:	Loads maintained at levels to allow compliance with local/state/federal WQ standards and criteria and/or ecological optimum
Threshold Target:	A research Question Note: eventual determination TMDL Criteria
Response:	Same as WQ- nutrients

Constraints:	- Reliability of automated sampling equipment - Sampling interval to allow characterization of short and long term loading - Equipment cost (number of sites needing monitoring)- flow meters and automated samplers - Non-point sources- groundwater, sheet flow, ocean, etc.- diffuse, variable
Status:	- SFWMD, flow weighted sampling in (?Eastern), Ongoing (?) Everglades - USGS Studies on nutrient loading to BISC Bay (Past) - SFWMD/ USGS ongoing flow monitoring in Fl Bay (Ongoing) - SFWMD- Doppler flow measurements @ control structures (verification of rating curves) - Model under development
Estimated Cost:	Potentially large, at least until calibrated/verified models can be used
References:	Clinton Hittle (USGS), Dan Childers, Rick Alleman (SFWMD), Stephen Blair (DERM)

J. *Surface Water Quality- physiochemical surface water characteristics at specific locations.*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ BUIS ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Surface Water Quality- physiochemical surface water characteristics at specific locations.
Monitoring Question(s):	What are the spatial and temporal distributions of nutrients and physical characteristics at specific sites in the wet prairies and marshes and into tidal areas?
Justification:	Nutrients and physical characteristics within the water body drive primary production and when unbalanced can have deleterious effects. Understanding the distribution of nutrients and physical characteristics allows more complete interpretation of other indicators. Many sites have had continuous sampling at specific locations for a number of years. Nutrient enrichment in freshwater and brackish areas has occurred primarily due to agricultural inputs (South Florida, US Virgin Is) with some impacts due to malfunctioning septic systems (US Virgin Is.). Everglades restoration is expected to reduce nutrient inputs to the Greater Everglades system.
Metric:	Total and soluble nutrients and pH, dissolved oxygen, conductivity, temperature, selected metals, salinity and chlorophyll, turbidity, photosynthetically active radiation (PAR), light extinction, etc.
Method:	- Grab sampling utilizing EPA/SM analysis - Continuous measures - limited parameter suite by Hydrolab-type units - Utilizing historic sampling stations and/or establish protocols and networks where needed.
Frequency:	Continuous- potential for selected parameters - Hydrolab-type, Event specific (high/low flow events- e.g.. tropical systems/ drought, triggers based on abnormalities for example during periods of water ascension/recession).
Timing:	All Year
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Park-wide: EVER, BICY, Site Specific
Scale of Analysis:	Park-wide: EVER, BICY, Site Specific
Basic Assumptions:	Water flow patterns can result in localized effects of nutrient concentrations.
Research Needs:	Synergistic effects of dissolved organic and inorganic (broad scope nutrients) on primary production (eutrophication). Bioavailability/ decomposition of Dissolved Organic Matter and subsequent release of nutrients. Water quality model development and downstream loading determination Internal cycling rates (P sequestration, denitrification, N2 fixation)
Management Goal:	Appropriate levels and ratios to maintain historic vegetation patterns and trophic structure.
Threshold Target:	Meet all local, state, and federal water quality standards and criteria. - Specific dissolved/ total/ inorganic/ organic phosphorus, carbon, and nitrogen targets
Response:	Feasibility of upstream control?

	Review/ evaluation of "operations"/ flow patterns
Constraints:	- Limited control of inputs from upstream - Balance between needed water volume/ flow and water quality/ nutrient loading - Station matrix representation of site/ park/ regional scales
Status:	- SFWMD EVER WQ monitoring - SFWMD Stage and rainfall monitoring - Utilize/ augment existing programs
Estimated Cost:	Hydrolab Datasonde ($2K each) Sample analysis (nutrients) $60 each
References:	Len (FIU), Tom (SFWMD), Brian (NPS). Jim Hendee (Coral List guy - NOAA) Cruis station at Salt River.

K. *Contaminants in water column, organisms, and sediments.*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior
☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑
DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Contaminants in water column, organisms, and sediments.
Monitoring Question(s):	What are the distribution, range, variability, concentrations of contaminants - including EPOCS (PPCP's - Pharmaceuticals and Personal Care Products), Endocrine disruptors and metals in the water column, organisms, and sediments (surface and core)?
Justification:	Point source and non-point source contaminants are a growing concern in most natural areas. Determining a proper monitoring protocol to establish a baseline and determine trends in contaminants is critical for proper resource management, especially in regards to modifications of water management from Everglades Restoration. Mercury bioaccumulation in particular is serious concern in the greater Everglades system.
Metric:	- Concentrations of conventional contaminants Hg (Total/Methyl); Metals, Hydrocarbons, PAHs, Pesticide/Herbicide/Insecticide, PCB's - Concentrations of EPOCs (Pharms, Caffeine, Estrogen/hormone related), non-regulated contaminants (vessel anti-fouling paint) - Grain size dependant
Method:	- Tissue analysis for conventional contaminants - Water Quality grab samples (in association with fish tissue sampling locations) for EPOCS - Tissue analysis should include resident (high site fidelity) and more broadly ranging species - Grab samples of water and sediment analyzed for contaminants - look at EPA EMAP SOP's o Sediment toxicity evaluations - Stratified random sampling (coastal inputs to open bay) - U.S. FWS or NOAA QA/QC and methods may be good starting point
Frequency:	Annual- Water Quality- Every 2 years for EPOCs, Every 4 years for sediment/ tissue analysis, Sampling frequency dependant on what is initially found
Timing:	Same time of year Across sampling periods - look at major use times (Columbus Day Regatta, Lobster Mini season, look at when partners are sampling
Scale of Collection:	Regional (incl. areas outside parks), Park-wide
Scale of Operation:	Regional (incl. areas outside parks), Site Specific: Basin?
Scale of Analysis:	Regional (incl. areas outside parks), Park-wide, Other (Please specify): Episodic
Basic Assumptions:	- Assessed organisms bioaccumulate contaminants of concern - Sediments serve as a sink for contaminants - Sediments contaminant levels are a surrogate of past exposure - Chemicals analyzed are the ones causing the greatest problems

Research Needs:	Effects of EPOCs and mode of action of EPOC's on animals, transient effects of EPOC's and contaminants What are biological thresholds for contaminants of concern
Management Goal:	No contaminants in Natural Waters or organisms, less than benchmark of concern for contaminants in water or sediment - look to level that causes no harm
Threshold Target:	- Meet all state/federal WQ and SQC standards - Reduction of contaminant in tissues sufficient to remove "fish consumption" limits, to protect biological/ecological integrity
Response:	Determine/mitigate to extent possible Source of Problem
Constraints:	- Sediments are spatially variable- sample number and location sufficient to adequately describe extent and pattern of contaminant levels - Selection of appropriate species for - Expensive! - Variability - Sample preservation, and analysis logistics
Status:	- DERM- County-wide canal sediment contaminants and toxicity (ongoing- every 5 years) - NOAA Biscayne Bay Sediment " (1995) -CCMA in Carib. - SFWMD/DERM County-wide and Bay Surface water Quality (ongoing) - SFWMD- Quarterly pesticide of canals entering the Bay - USDA- Surface Water- bimonthly?- pesticides/herbicides o South Dade "transects" from Everglades to Elliott Key - NPS- CESI- study EVER, BISC, BICY, various contaminants - USGS- EPOCs study (200 4/5)
Estimated Cost:	EPOC's ~$1400/sample Contaminants ~$1000/sample
References:	Susan Markley (DERM), Clint Lietz (USGS), Richard Pieffer (SFWMD), Ramona (USDA), Piero Gardinelle (NPS), NOAA CCMA, USFWS website, John Christiansen, Bill Loftus, Joel Trexler, Tina Ugarte, Roy Irwin

L. *Phytoplankton composition and biomass*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ DRTO ☑ EVER

Indicator:	Phytoplankton composition and biomass
Monitoring Question(s):	Is anthropogenic nutrient enrichment or other human associated disturbances causing algal blooms? Are blooms causing light extinction that is harmful to benthic habitat? Are blooms toxic/harmful (red tides)?
Justification:	Phytoplankton community composition and biomass reflect water quality, especially nutrient loading and water clarity. They are important primary producers in aquatic food webs, which when unbalanced by excessive nutrients respond quickly with algal blooms that reduce dissolved oxygen and cause light extinction that harms benthic habitat and fish. Some algal species can be especially harmful as in western Florida where harmful red tides have occurred and in the Florida keys where

	"black water" events have occurred.
Metric:	Primary - Chlorophyll a, other pigments (taxonomic indicator), microscopic validation of pigment indicator, possible bioassay for red tide (?), location, light extinction Secondary - From related program, nutrients (concentration and loading), DO variability, salinity - Cyanobacteria and red tide species as indicators of harmful algal blooms
Method:	Fluorometry, HPLC, (remote sensing of chlorophyll a?), in vivo field surveys; extracted fluorometry Microscopy
Frequency:	Monthly, also with events (higher frequency)
Timing:	N/A
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Pigments are good indicators of biomass and composition
Research Needs:	Attributing anthropogenic vs. natural forcing? Capability of red tide bioassays? Water quality model development Causes of bloom dynamics Information of limiting nutrients, (N, P, Si, Fe)
Management Goal:	Minimize anthropogenically driven blooms, especially as indirect consequence of environmental management
Threshold Target:	Varies with location (see RECOVER and Fl Bay and Keys Feasibility Study performance measures)
Response:	Improved nutrient treatment?
Constraints:	-See research needs regarding cause and effect -Frequency of blooms (high variability) -Model capability
Status:	-SFWMD/FIU WQ monitoring -DERM/SFWMD -Mote/ FKNMS/EPA/FIU -FWRI- (HAB) -NOAA/AOML/RSMAS- Mapping -SFWMD Model development
Estimated Cost:	Included in overall water quality monitoring = $1M- $20M, but extra ~$200,000 for detailed composition non-chlor pigments (best guess)
References:	Joe Boyer, Karen Steidinger, Gary Hitchcock, Gabe Vango, Ed Philips, Cindy Heil

M. *Invasive exotic plants*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior

☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑

DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Invasive exotic plants
Monitoring Question(s):	Are invasive exotic plants increasing in extent or are new invasive species becoming established in or near the park with potential to become invasive?
Justification:	Invasive plants are one of the most serious threats to maintaining ecosystem integrity in the South Florida and Caribbean parks. Not only is tracking the distribution, rate of spread and control of known invasive species important to assessing the health of the system for supporting native species, but detecting new species with the potential to become invasive while they are still in small controllable populations is important to cost-effective management of this problem. Executive Order 13112 deals with the introduction, spread, control, and monitoring of invasive species on federal lands.
Metric:	Number of species established Areal extent of invasion by species Vegetation types invaded Number of new species near or in park Risk factor for invasion of a new species
Method:	See Science Coordination Group development of invasive plant indicator There are gaps in coverage of the SCG indicator. It does not cover BISC, or western BICY
Frequency:	Annual
Timing:	Winter after leaf fall for deciduous species
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Invasive species are continuing to spread and invade and are altering native ecosystem properties and functions
Research Needs:	Development of a risk assessment tool for south Florida plants and animals and a detailed listing of species that may pose future threats in order to do a risk assessment. Need an understanding of the biology of individual species and work for biocontrol of species (see USDA and SFWMD)
Management Goal:	No new species invading, reduction in extent of existing invasive species
Threshold Target:	No exotic species present or contraction in extent of existing species and no new species
Response:	Active management program to reduce populations
Constraints:	Need to determine invasive risk potential of a species new to the area. Need to determine how to kill a species and prevent its further spread.
Status:	Some work is being done, See EPA REMAP, SFWMD-USFWS-NPS SRF, SCG indicator, SFWMD tree island survey and SFWMD Vegetation mapping project. Also Florida Exotic Pest Plant Council and the COE Master Invasive Species Plan.
Estimated Cost:	Varies but see different existing projects

Synthesis of existing information and filling spatial and temporal gaps in existing projects

References: LeRoy Rodgers, Ken Rutchey SFWMD, John Volin FAU, Jenny Richards & Tom Philippi & Bob Doren FIU, Tony Pernas, Jonathan Taylor, Skip Snow NPS

N. *Invasive exotic fauna*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior
☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑
DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Invasive exotic fauna
Monitoring Question(s):	What exotic animal species are present in the parks and which ones are considered invasive or otherwise problematic? What is the distribution of the species and level of control and how is this changing? Are new invasive species becoming established in or near the park? How are they affecting native species and habitats?
Justification:	Invasive fauna are one of the most serious threats to maintaining ecosystem integrity in the South Florida and Caribbean parks. At least 61 exotic species are currently found within the network parks. Some of the most problematic include pythons, hogs, rats, mice, mongoose, Mayan cichlid, Cuban tree frogs, loose and feral livestock, lac lobate scale, and fire ants. Tracking the distribution and level of control of known invasive species is important to assessing the health of the system for supporting native species. In addition, detecting new species with the potential to become invasive while they are still in small controllable populations is important to cost-effective management. Island food-webs are particularly susceptible to invasive species, but also offer some of the best opportunities for successful control. Executive Order 13112 deals with the introduction, spread, control, and monitoring of invasive species on federal lands. Note: Indicator "Early detection, status, and trends of non-indigenous aquatic species" is similar but has a more specific focus on non-indigenous aquatic species in south Florida and detailed methodology.
Metric:	Number of species established Locations/distribution where detected Trends in distribution of established species Vegetation types invaded Number of new species detected near or in park Risk factor for invasion of a new species
Method:	• Monitor for new species at likely entry points (park boundaries, boundary canals, areas of high commercial or recreational boat traffic). • Record new sightings detected during other monitoring and management activities. • As problematic species are identified, target methods to that species to assess distribution and/or abundance and assess changes as appropriate (for species whose distribution is park-wide and no control exists, detailed monitoring is not recommended as it yields no useful information).
Frequency:	Annual
Timing:	As appropriate by species
Scale of Collection:	Multiple Parks, Site Specific
Scale of Operation:	Regional (incl. areas outside parks)
Scale of	Regional (incl. areas outside parks), Multiple Parks, Site Specific

Analysis:

Basic Assumptions:	Some invasive species are established (e.g. pythons, hogs, rats, mice, mongoose, Mayan cichlid, Cuban tree frogs, loose and feral livestock, lac lobate scale, and fire ants) and are already altering native ecosystem properties and functions. New invasive species could establish due to released pets, ornamental plant trade, exotic food trade, fishing bait, boats hulls, ship ballast water releases, and freak accidents during hurricanes and tropical storms both within and outside the parks.
Research Needs:	Development of a risk assessment tool for south Florida plants and animals and a detailed listing of species that may pose future threats in order to do a risk assessment. Need an understanding of the biology of individual species and work for biocontrol of species (see USDA and SFWMD)
Management Goal:	No new species invading, reduction in extent of existing invasive species
Threshold Target:	No exotic species present or contraction in extent of existing species and no new species
Response:	Active management program to reduce populations
Constraints:	Need to determine invasive risk potential of a species new to the area. Need to determine how to remove a species and prevent its further spread.
Status:	Project-specific monitoring - i.e. elimination of mongoose, rats, and mice on Buck Island; control efforts for pythons in Everglades; rats at DRTO; monitoring at BISC for Mexican red-bellied squirrel
Estimated Cost:	Varies but see different existing projects Synthesis of existing information
References:	Tony Pernas (NPS-EPMT), Skip Snow (NPS-EVER), Jeff Kline (NPS-EVER)

O. *Early detection, status, and trends of non-indigenous aquatic species.*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Early detection, status, and trends of non-indigenous aquatic species.
Monitoring Question(s):	1. The early detection of non-indigenous species outside of NPS boundaries in support of management actions to prevent the introduction and establishment of non-native species with NPS boundaries. 2. The early detection of non-indigenous species within NPS boundaries to facilitate management actions to prevent establishment. 3. Tracking the status and trends of non-indigenous populations both within and outside of NPS boundaries.
Justification:	There are over 100 non-indigenous aquatic species that have been introduced in South Florida. Establishment and displacement of native fauna is a real management concern. In addition some invasive non-indigenous species have the potential for greatly changing aquatic food web functioning. Detecting new species with the potential to become invasive while they are still in small controllable populations and/or outside park boundaries is important to cost-effective management of this problem. Executive Order 13112 deals with the introduction, spread, control, and monitoring of invasive species on federal lands.

Metric:	Number of non-indigenous species both within and along the boundary of NPS lands. Changes in non-native species composition outside ENP boundaries. Changes in numbers and population sizes of non-native species within ENP.
Method:	Common fisheries survey techniques: Electrofishing, trapping, netting. Methods chosen should be proven to collect a large diversity of species to increase the probability of detecting new species in the system.
Frequency:	Annual
Timing:	Annually at a minimum. During the dry season when fishes are concentrated in canals along the border. During the wet season within ENP boundaries to detect populations on the marsh surface.
Scale of Collection:	Other (Please specify): Includes both within NPS boundaries lands and canals bordering.
Scale of Operation:	Other (Please specify): Includes both within NPS boundaries lands and canals bordering.
Scale of Analysis:	Other (Please specify): Includes both within NPS boundaries lands and canals bordering.
Basic Assumptions:	The S. Florida canal system is key source of aquatic non-indigenous species within ENP.
Research Needs:	Research techniques for delivering water without delivering non-indigenous species.
Management Goal:	Reduce the rate of increase in numbers of new non-indigenous species entering and becoming established within NPS lands. Reduce the total number of non-indigenous species established within NPS lands. Monitoring that provides early detection and changes in the distribution of non-native species to support management actions that prevent the spread into ENP lands and tracks the distribution of species once introduced.
Threshold Target:	No new non-indigenous species within NPS lands. Use existing numbers of species to base changes against.
Response:	Determine if there are viable alternatives to how water delivery is accomplished. Facilitate cooperation between state and federal agencies to meet the mandates of federal lands where non-indigenous species are concerned.
Constraints:	South Florida Parks need water and it seems that there will always be canals with non-indigenous species in South Florida.
Status:	Some monitoring exists within Everglades National Park boundaries. There is no consistent monitoring effort in the border canals and lands to ENP.
Estimated Cost:	
References:	

P. *Coral Communities*

Which conceptual model(s) is this indicator linked to?

☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ SARI ☑ VIIS

Indicator:	Coral Communities
Monitoring Question(s):	How do coral communities change over time within parks and outside of park? How are percent cover, species diversity, rugosity, abundance, spatial extent, recruitment, disease, mortality, calcification, structure, and algal community structure changing? How do communities compare among areas with differing management regimes?
Justification:	The coral reef communities within the South Florida / Caribbean Network represent some of the best examples of Caribbean and Western Atlantic Coral reefs within the National Park Service. The enabling legislation and/or presidential proclamations for VIIS, BUIS and DRTO specifically mention coral reefs within these park units as significant environmental communities. The reefs support incredible diversity, including endangered sea turtles, conchs and lobsters. Monitoring coral reefs was identified as a national priority by President Clinton's Executive Order 13089 establishing the Coral Reef Initiative. These coral reefs are negatively impacted by unusually high water temperatures that cause "bleaching", coral disease, overfishing, vessel scarring, major storms, and in some cases by sedimentation and nutrient enrichment.
Metric:	Percent cover, species diversity, rugosity, abundance, spatial extent, recruitment, disease, mortality, calcification, structure, bio-erosion, episodic assaults (bleaching)
Method:	Video transects, quadrats (photo/visual), colonies, area surveys.
Frequency:	Annual, episodic, to be determined
Timing:	consistent dates.
Scale of Collection:	Regional, Multi-park, site specific, external to park
Scale of Operation:	Regional
Scale of Analysis:	Regional, park, site specific
Basic Assumptions:	Independence or linkage Monitoring reflects the population- appropriate timing and methodology Revisit during protocol development.
Research Needs:	- Relation of demographics to observable information - Determine a threshold target - species specific - Identify sensitive species - Larval transport - Inventory of deep. - Microbial communities.
Management Goal:	Coral community integrity Sustainable recreation Sustainable fisheries

Sustainable water quality

Threshold Target:	
Response:	- sound alarm - organize task force - education/outreach - mitigation
Constraints:	Is this sampling design appropriate in predicting population estimates? [precision] Costs of high precision sampling design Uncertainty in estimates Number of qualified research experts. Decadal processes limit ability to show trend.
Status:	Ongoing (NOAA, FWC, NPS, USGS, EPA, Universities, NGO's, etc)
Estimated Cost:	Park/Method/Intensity specific
References:	Contact: Jeff Miller, Caroline Rogers, Chris Jeffries.

Q. *Seagrass and other SAV cover and community composition*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Seagrass and other SAV cover and community composition
Monitoring Question(s):	What is the location, distribution, extent, habitat quality of SAV habitat? How does SAV habitat vary along onshore-offshore, longshore gradients over time and depths? How is community composition changing over time?
Justification:	Communities of seagrass and other submerged aquatic vegetation (SAV) cover large portions of 6 parks within the South Florida / Caribbean Network. These habitats support a wide diversity of vertebrate and invertebrate life and provide connectivity pathways between nearshore and offshore habitats. They are also important nursery areas for many marine species. Community composition is related to salinity levels, light extinction, the distribution of soft-bottom and hard-bottom sediments, nutrient enrichment, water quality (e.g. sulfides, redox), disease, level of disturbance, and succession. The 1987 seagrass die-off in Florida Bay had cascading effects on the ecosystem.
Metric:	Primary: Modified Braun- Blanquet cover index, species composition (including both seagrass and macroalgae), location, depth, salinity, sediment depth, canopy height. density Secondary (from related programs)- light extinction, nutrients, N:P ratio in Thallasia blades, epiphytes, sulfide toxicity, redox, slime mold disease
Method:	See RECOVER (Durako and Fourqurean)- Diver Potential for video transects Belts, Quadrats. See also NPS protocol
Frequency:	Monthly- min. semi-annual (all sites) Quarterly (subset of all sites), Annual
Timing:	Wet season, dry season (focus on salinity min/max)
Scale of	Regional (incl. areas outside parks), multiple parks, site specific

Collection:	
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks), Site Specific: meter square to 10-100 hectares
Basic Assumptions:	-Sensitive to stressors -Relevant to food web -Braun Blanquet methodology is sufficiently quantitative -Coordinated with salinity and other measurements
Research Needs:	Effects of macro-nutrients on species composition. Effects of salinity variance on species comp. Video transect Braun Blanquet calibration/ verification. Interspecific species competition relationships. Relationship of importance of habitat quality to upper trophic levels. E.g.. Diversity, etc)
Management Goal:	At a minimum, maintain marshes, seagrass species abundance, and distribution. Rehabilitate a diverse and sustainable habitat
Threshold Target:	General target of high cover where SAV can grow (e.g.. with sediments), moderate density, high diversity. "Threshold" level undetermined at this time.
Response:	Insufficient knowledge, but salinity and nutrient management are likely focus for action
Constraints:	Semi-quantitative nature of Braun-Blanquet Calibration among sampling teams/ field workers Continued model development (in progress) Larger scale spatial relationships (need for remote sensing, mapping)
Status:	Some existing monitoring exists in Fl Bay and BISC Bay by Miami- Dade DERM and FIU, UNCW (Duracho). (RECOVER, SFWMD funding) USVI on-going In Comprehensive Monitoring Restoration Plan (CERP) Monitoring and Assessment Plan (MAP) and is an Interim Goals indicator.
Estimated Cost:	$500,000/ yr
References:	Jim Fourqurean (FIU), Penny Hall (FWRI), Duraco (UNCW), S. Blair (MD DERM), B. Miller, Chris Jeffery

R. *Benthic community spatial & temporal changes in extent and distribution -remote sensing*

Which conceptual model(s) is this indicator linked to?

☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Benthic community spatial & temporal changes in extent and distribution -remote sensing
Monitoring Question(s):	What are the baseline conditions in the extent and distribution of major benthic communities and how are they changing (e.g. hardbottom, soft-bottom, dense Thallasia sp. seagrass, sparse seagrass, etc)? Where are areas of impact occurring (visitor use, canal discharges)? Are abnormal/episodic changes occurring?
Justification:	The extent, distribution, and composition of major benthic communities (e.g. hardbottom, soft-bottom, dense Thallasia sp. seagrass, sparse seagrass, etc.) across bays and marine areas are a strong influence on the fish, invertebrate, and larger vertebrate communities (e.g. sea turtles, manatees) they support. These can change with alterations in location, quantity and quality of freshwater and sediment inputs (e.g. Comprehensive Everglades Restoration Plan), nutrient levels, major storm events, and heavy visitor use (e.g. repeated boat groundings, scarring, and anchoring damage). Analysis of remotely-sensed data provides the spatial extent and composition of major benthic communities across relevant areas of marine parks allowing tracking of changes in large-scale patch size and shape at a broader scale than site-specific studies.
Metric:	Changes in large-scale patch size and shape with field sampling to ground-truth species composition of benthic patches
Method:	GIS low level aerial imagery or submerged georeferenced imagery polygons that are analyzed for shape, size, and spatial relationships Example: Underwater georeferenced videos, diver surveys, acoustic
Frequency:	To be determined
Timing:	To be determined
Scale of Collection:	Regional (incl. areas outside parks), Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Park-wide, may also be local in relation to events or inputs- e.g.. Canals or boat groundings
Scale of Analysis:	Regional (incl. areas outside parks), Park-wide
Basic Assumptions:	The underlying assumption is that there is some characteristic suite of benthic communities that exist in relation to each other in some characteristic or consistent way that may change if faced with a significant perturbation or abnormal conditions.
Research Needs:	This information is needed to verify a seagrass model Understand sources of change (baseline conditions) in various benthic communities
Management Goal:	To maintain a mosaic of natural benthic habitats.
Threshold	Insufficient Knowledge

Target:

Response: Determine source of change. Once source of change is known, act on it if possible.

Constraints: Must sample with enough frequency to clearly characterize a baseline condition. Best if also used in conjunction with a detailed complex seagrass model. This could be used to look at influences on changes in macro-algal communities, shifts in hardbottom, and increases in mud bottoms.

Status: -Some sampling is currently funded for submerged imaging within BISC and some reef sampling. SWAP's in BISC Bay by UM RSMAS
-FDEP/MAP-CERP currently developing benthic map of entire BISC and Fl Bay area. Not used in fine scale
-Benthic habitat maps, fine-scale in-situ data collection on-going. - USVI
-Side-Scan Sonar, Multi-beam and ROV work ongoing. - USVI

Estimated Cost:

References:

S. *Marine Fish Communities - Coastal Shelf / Deep oceanic - Status, structure, trends*

Which conceptual model(s) is this indicator linked to?

☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Marine Fish Communities - Coastal Shelf / Deep oceanic - Status, structure, trends
Monitoring Question(s):	How do fish communities change over time within parks outside of parks? Does the species integrity persist? What is the location and integrity of spawning aggregations? How do communities compare among areas with differing management regimes? How do juvenile communities change over time?
Justification:	Fish communities in the coastal shelf and oceanic areas are an important higher trophic level of the marine system that are additionally valued by humans as fisheries. Community status, structure and trends reflect changes in marine habitat quality, connectivity, fishing pressure, and long-term ecosystem resilience. The status of fish communities also affects seabird communities and large marine vertebrates. Balancing resource extraction with sustainability is a key management concern. The impacts of fishery management tools such as "no-take" zones are of high interest to resource management and the public. Several fish species within parks are at or near local or regional extirpation.
Metric:	Fish community recruitment, abundance, size, species, species composition, fishing pressure, biomass Spawning aggregation characteristics
Method:	Fishery dependent- monitoring recreational and commercial catch Fishery independent- visual census, acoustics, optics, nets, trawls, traps Methods may need to be focused to answer targeted spp questions?
Frequency:	Annual to quarterly; lunarly.
Timing:	Depending on seasonal spatial distribution.
Scale of Collection:	Regional, Multi-park
Scale of Operation:	Regional/ Multi-park
Scale of Analysis:	Multi-park/ Park/ Habitat
Basic Assumptions:	Independence or linkage Monitoring reflects the population- appropriate timing and methodology
Research Needs:	To better understand the sustainability of the community: Natural History/Demographics of non-exploited species Connectivity
Management Goal:	Fish community integrity Sustainable fishing and other recreation Viable spawning aggregations
Threshold Target:	Increased predator base Increased herbivores

	To be determined
Response:	Reduce impacts of principal stressors: Collaborate with other agencies Internal response
Constraints:	Is this sampling design appropriate in predicting population estimates? [precision] Costs of high precision sampling design We know the measurement generally reflects population changes, the level of accuracy and precision is cost dependent.
Status:	Ongoing (NOAA, FWC, NPS, Universities, NGO's, etc)
Estimated Cost:	Park/Method/Intensity specific
References:	Contact: J. Bohnsack, J. Ault, C. Menza

T. *Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Throw trap*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Throw trap
Monitoring Question(s):	What are baseline conditions, variability, and trends in nearshore and estuarine fish communities?
Justification:	Fish communities in nearshore estuaries are a critical component of the ecosystem. Community status, structure and trends reflect changes in marine habitat quality, connectivity, fishing pressure, and long-term ecosystem resilience. Several fish species within parks are at or near local or regional extirpation. Differing sampling methodologies target different portions of the fish community. Our fisheries experts advocate using consistent methodologies across the region for increased data comparability, but recommended evaluating them independently through this ranking process. This indicator refers to "throw trap" methods. "Visual assessment", "seining", "trawling", and "other trapping" are covered in other indicator worksheets.
Metric:	Taxonomic composition, T. Richness, T. Diversity, T. Evenness, habitat and sediments (?), T. dominance (spatial and temporal distribution), trophic classification, index of trophic complexity
Method:	Throw trap
Frequency:	Monthly- pilot, seasonal after pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	
Basic Assumptions:	- Consistency in sampling design and sampling methods - Consistency in protocol - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Optimal diverse and productive community
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power

Status:	Ongoing in BISC and EVER through MAP
Estimated Cost:	~$250k/park/year MAP covers BISC and EVER
References:	Joe Serafy Joan Browder Mike Robblee Todd Hopkins

U. *Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Trawling*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ DRTO

Indicator:	Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Trawling
Monitoring Question(s):	What are baseline conditions, variability, and trends in nearshore and estuarine fish communities??
Justification:	Fish communities in nearshore estuaries are a critical component of the ecosystem. Community status, structure and trends reflect changes in marine habitat quality, connectivity, fishing pressure, and long-term ecosystem resilience. Several fish species within parks are at or near local or regional extirpation. Differing sampling methodologies target different portions of the fish community. Our fisheries experts advocate using consistent methodologies across the region for increased data comparability, but recommended evaluating them independently through this ranking process. This indicator refers to "trawling" methods. "Visual assessment", "seining", "throw traps", and "other trapping" are covered in other indicator worksheets.
Metric:	Taxonomic composition, T. Richness, T. Diversity, T. Evenness, habitat and sediments (?), T. dominance (spatial and temporal distribution), trophic classification, index of trophic complexity
Method:	Trawling
Frequency:	Monthly- pilot, seasonal after pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	
Basic Assumptions:	- Consistency in sampling design and sampling methods - Consistency in protocol - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Optimal diverse and productive community
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing in BISC and EVER through MAP

Estimated Cost: ~$250k/park/year
MAP covers BISC and EVER

References: Joe Serafy
Joan Browder
Mike Robblee
Todd Hopkins
Ron Hill (NIMPS) Texas worked in St. John not in mangroves
Ivan Mateo (U of Rhode Island) Sea Nimph project at Salt River. Otoliths (ear bone chemistry) for connectivity.

V. *Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Seining*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Seining
Monitoring Question(s):	What are baseline conditions, variability, and trends?
Justification:	Fish communities in nearshore estuaries are a critical component of the ecosystem. Community status, structure and trends reflect changes in marine habitat quality, connectivity, fishing pressure, and long-term ecosystem resilience. Several fish species within parks are at or near local or regional extirpation. Differing sampling methodologies target different portions of the fish community. Our fisheries experts advocate using consistent methodologies across the region for increased data comparability, but recommended evaluating them independently through this ranking process. This indicator refers to "seining" methods. "Visual assessment", "trawls", "throw traps", and "other trapping" are covered in other indicator worksheets.
Metric:	Taxonomic composition, T. Richness, T. Diversity, T. Evenness, habitat and sediments (?), T. dominance (spatial and temporal distribution), trophic classification, index of trophic complexity
Method:	Seining
Frequency:	Monthly- pilot, seasonal after pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	
Basic Assumptions:	- Consistency in sampling design and sampling methods - Consistency in protocol - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Optimal diverse and productive community
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power

Status: Ongoing in BISC and EVER through MAP

Estimated Cost: ~$250k/park/year
MAP covers BISC and EVER

References: Joe Serafy
Joan Browder
Mike Robblee
Todd Hopkins
Ron Hill (NIMPS) Texas worked in St. John not in mangroves
Ivan Mateo (U of Rhode Island) Sea Nimph project at Salt River. Otoliths (ear bone chemistry) for connectivity.

W. *Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Visual Assessment*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Visual Assessment
Monitoring Question(s):	What are baseline conditions, variability, and trends in nearshore and estuarine fish communities?
Justification:	Fish communities in nearshore estuaries are a critical component of the ecosystem. Community status, structure and trends reflect changes in marine habitat quality, connectivity, fishing pressure, and long-term ecosystem resilience. Several fish species within parks are at or near local or regional extirpation. Differing sampling methodologies target different portions of the fish community. Our fisheries experts advocate using consistent methodologies across the region for increased data comparability, but recommended evaluating them independently through this ranking process. This indicator refers to "visual assessment" methods. "Seining", "trawls", "throw traps", and "other trapping" are covered in other indicator worksheets.
Metric:	Taxonomic composition, T. Richness, T. Diversity, T. Evenness, habitat and sediments (?), T. dominance (spatial and temporal distribution), trophic classification, index of trophic complexity
Method:	Visual Assessment
Frequency:	Monthly- pilot, seasonal after pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	
Basic Assumptions:	- Consistency in sampling design and sampling methods - Consistency in protocol - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Optimal diverse and productive community
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support

Skilled man power

Status: Ongoing in BISC and EVER through MAP

Estimated Cost: ~$250k/park/year
MAP covers BISC and EVER

References: Joe Serafy,
Joan Browder,
Mike Robblee,
Todd Hopkins,
Ron Hill (NIMPS) Texas worked in St. John not in mangroves
Ivan Mateo (U of Rhode Island) Sea Nimph project at Salt River. Otoliths (ear bone chemistry) for connectivity.

X. *Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Other trapping*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Marine Fish Communities - Bays/Mangroves - Status, structure, trends - Other trapping
Monitoring Question(s):	What are baseline conditions, variability, and trends in nearshore and estuarine fish communities?
Justification:	Fish communities in nearshore estuaries are a critical component of the ecosystem. Community status, structure and trends reflect changes in marine habitat quality, connectivity, fishing pressure, and long-term ecosystem resilience. Several fish species within parks are at or near local or regional extirpation. Differing sampling methodologies target different portions of the fish community. Our fisheries experts advocate using consistent methodologies across the region for increased data comparability, but recommended evaluating them independently through this ranking process. This indicator refers to methods other than "seining", "trawls", "visual surveys", and "throw traps" which are covered in other indicator worksheets.
Metric:	Taxonomic composition, T. Richness, T. Diversity, T. Evenness, habitat and sediments (?), T. dominance (spatial and temporal distribution), trophic classification, index of trophic complexity
Method:	Other trapping
Frequency:	Monthly- pilot, seasonal after pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	
Basic Assumptions:	- Consistency in sampling design and sampling methods - Consistency in protocol - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Optimal diverse and productive community
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support

Skilled man power

Status: Ongoing in BISC and EVER through MAP

Estimated Cost: ~$250k/park/year
MAP covers BISC and EVER

References: Joe Serafy
Joan Browder
Mike Robblee
Todd Hopkins
Ron Hill (NIMPS) Texas worked in St. John not in mangroves
Ivan Mateo (U of Rhode Island) Sea Nimph project at Salt River. Otoliths (ear bone chemistry) for connectivity.

Y. *Exploited Fish Assemblage - Grouper, Snapper, (parrotfish, surgeonfish in USVI)-population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Exploited Fish Assemblage - Grouper, Snapper, (parrotfish, surgeonfish in USVI)- population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends of Nassau Grouper/Snapper/Parrotfish/Surgeonfish? Are there differences among areas with different management regimes? Are no-take zones working?
Justification:	The exploited fish assemblage contains intermediate and higher trophic level piscivores although herbivores are added in heavily fished US Virgin Is. These species are under heavy fishing pressure within and outside SFCN parks boundaries. Community status, structure and trends for exploited fish can reflect changes in marine habitat quality, food-web structure, fishing pressure, and long-term ecosystem resilience. Balancing resource extraction with sustainability is a key management concern. The impacts of fishery management tools such as "no-take" zones are of high interest to resource management and the public. Several fish species within parks are at or near local or regional extirpation.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Creel Surveys - Visual Surveys - Fisheries dependant monitoring - Tagging - Refer to USGS/NOAA/NPS fish monitoring protocol
Frequency:	Annual, Other (Please specify): - pilot, sustained to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot, consistent dates
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks), Park-wide, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - Protocol consistency - Consistency of data collection and data quality control
Research	Connectivity questions

Needs:	
Management Goal:	Productive and resilient population If exploited species- sustainability
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled human power
Status:	Ongoing
Estimated Cost:	$50k/park/year Can be combined with other studies
References:	Joe Serafy, Tom Schmidt, Mike Robblee, Joan Browder, Charlie Menza

Z. *Snook - population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ DRTO ☑ EVER

Indicator:	Snook - population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends of snook?
Justification:	The snook (Centropomus undecimalis) is a euryhaline, diadromous, estuarine-dependent species targeted as a sport fish and for human consumption within and outside SFCN parks boundaries. They are under strong fishing pressure. Prey source varies with life stage (juveniles - small fish, plants; adults -fish, crabs). Community status, structure and trends can reflect changes in marine habitat quality, food-web structure, fishing pressure, and long-term ecosystem resilience. Balancing resource extraction with sustainability is a key management concern.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Creel Surveys - Visual Surveys - Seining
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive, resilient, and sustainable populations
Threshold Target:	Will be determined by baseline analysis

Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing EVER and BISC
Estimated Cost:	~$150k/park/year Can be combined with other studies
References:	

AA. *Bonnethead, Lemon, Bull, Nurse Sharks - population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ DRTO ☑ EVER

Indicator:	Bonnethead, Lemon, Bull, Nurse Sharks - population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends in Bonnethead (Sphyrna tiburo), Lemon (Negaprion brevirostris), Bull (Carcharhinus leucas), and Nurse (Ginglymostoma cirratum) sharks?
Justification:	Sharks, as top marine food-web predators, have been fished to such an extent that their numbers are reduced in south Florida and they have been virtually eliminated from the US Virgin Islands. Sharks mature late in life, have slow growth rates and produce few offspring. As top predators they reflect the condition of the marine food web. Larger fish such as these are targets of fisherman, and thus appropriate management for sustainable fisheries is a concern.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Creel Surveys - Long Line
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive, resilient, and sustainable populations
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term

Support
Skilled man power

Status: Ongoing in DRTO and EVER

Estimated Cost: ~$150k/park/year
Can be combined with other studies

References: Joe Serafy, Mike Robblee, Joan Browder

BB. *Spotted Sea Trout - population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ DRTO ☑ EVER

Indicator:	Spotted Sea Trout - population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends of snook?
Justification:	The spotted sea trout (Cynoscion nebulosus) is a bottom-feeding intermediate trophic level species targeted as a sport fish and for human consumption within and outside SFCN parks boundaries. This is the only major sport fish in south Florida that spends its entire life cycle in bays. They are sensitive to hypersaline conditions and thus may respond to changes in south Florida water management restoration. Community status, structure and trends for the spotted sea trout can reflect changes in marine habitat quality, food-web structure, fishing pressure, and long-term ecosystem resilience. Balancing resource extraction with sustainability is a key management concern. Mercury bioaccumulation is also a concern.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Creel Surveys - Small otter trawl - Commercial catch per unit effort
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive, resilient and sustainable populations
Threshold	Will be determined by baseline analysis

Target:	
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing in EVER only
Estimated Cost:	~$150k/park/year Combined with other fish creel studies
References:	

CC. *Gray Snapper (Schoolmaster in VI)- population structure, status, & trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Gray Snapper (Schoolmaster in VI)- population structure, status, & trends
Monitoring Question(s):	What are baseline conditions, variability, and trends of gray snapper/schoolmaster?
Justification:	The gray snapper (Lutjanus griseus)/schoolmaster (Lutjanus apodus) are intermediate trophic level species targeted for human consumption within and outside SFCN parks boundaries. Juveniles predominately reside in nearshore habitats and adults are found in the coastal shelf/reefs. Community status, structure and trends for snapper can reflect changes in marine habitat quality, food-web structure, fishing pressure, and long-term ecosystem resilience. Balancing resource extraction with sustainability is a key management concern.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Visual Census/ Shoreline visual survey - Trawls - Seining - Creel Surveys - Traps
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive, resilient and sustainable populations
Threshold	Will be determined by baseline analysis

Target:	
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing in BISC and NE Florida Bay, Previous work at USVI
Estimated Cost:	~$150k/park/year Seasonal Surveys
References:	Schoolmaster- nursery habitat, USVI - Visual and Traps (Rafe)., Large Gray Snapper in Mangroves and large Schoolmaster on Reef in USVI

DD. *Goliath Grouper (Red Hind in VI) - population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Goliath Grouper (Red Hind in VI) - population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends of goliath grouper/red hind?
Justification:	Goliath grouper (Epinephelus itajara), a top marine food-web predator, has been over-fished to such an extent that it is now rare and a protected species in the state of Florida. The goliath grouper has all but disappeared in the US Virgin Islands and as such red hind (Epinephelus guttatus) is recommended instead as a top-predator to monitor that is also under heavy fishing pressure. Larger fish such as these are popular targets of fisherman, and thus of particular concern for management and efforts to protect and manage these stocks are often used as indicators of success for marine protected areas.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Creel Surveys - Visual Surveys
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive, resilient, and sustainable populations
Threshold Target:	Will be determined by baseline analysis

Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing EVER
Estimated Cost:	~$150k/park/year Can be combined with other studies
References:	Joe Serafy, Mike Robblee, Joan Browder

EE. *Sawfish- population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ DRTO ☑ EVER

Indicator:	Sawfish- population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends for small-toothed sawfish?
Justification:	Small-toothed sawfish (Pristis pectinata) is a Federally Listed Endangered Species found in Everglades and Biscayne National Parks. This long-lived and large species (record is 18 feet in length) was formerly a fishery before stocks dwindled. Typically is found near and in estuaries, bays, and inlets utilizing seagrass, mud/sand bottom, oyster bars, reefs, and mangroves. Their saw makes them susceptible to entanglement in nets and lines. Little is known about this species, but, like other rays and sharks, they have limited reproductive potential.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration), secondary production, trophic level
Method:	- Creel Surveys - Long Line - Visual Surveys
Frequency:	Monthly- pilot project; long-term monitoring frequency be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Multiple Parks, Site Specific
Scale of Analysis:	Multiple Parks, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive and resilient population
Threshold Target:	Will be determined by baseline analysis

Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing in EVER
Estimated Cost:	~$150k/park/year Can be combined with other fish surveys
References:	Joe Serafy, Mike Robblee

FF. *Infaunal benthic community structure and abundance for animals*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ EVER

Indicator:	Infaunal benthic community structure and abundance for animals
Monitoring Question(s):	What is the distribution and abundance of important indicators and keystone organisms? What is the current distribution of organisms with respect to salinity and nutrient gradients?
Justification:	Infaunal benthic communities include bivalves (clams), worms (polychaetes and oligochaetes), amphipod crustaceans, insect larvae, etc., that live within the marine substrate. They are heavily preyed upon by crabs and fish. Community composition and structure differs with habitat, salinity, and dissolved oxygen. Community composition is sensitive to changes in water quality, particularly contaminants (e.g. pesticides, heavy metals), changing salinity, and dissolved oxygen (related to nutrient and organics enrichment). In addition to indicators of overall estuarine health in Florida and Biscayne Bays, they can potentially be valuable indicators in ecotonal areas or areas of suspected contaminant input. They show a response to the general water quality and contaminant levels at a site through time. However, while these communities have been uses as indices in other areas of the country, a south Florida index has not been developed yet.
Metric:	Sample the benthic communities species composition, abundance, distribution. Species richness/ diversity, number and organisms, species, location. Nutrients, Tp and SRP, DO, turbidity, salinity, temp, depth in sediment, type of sediment for benthic habitat Nutrient WQ sampling to be conducted in accordance with benthic monitoring
Method:	- Grab or core samples - Sediment and sediment sieves grain size, % organics, total organic, total inorganic carbon - Standard nutrient sampling using accepted lowest threshold min detection limits - Continuous salinity recording equipment measuring conductivity temperature in bottom water - Also sample in conjunction with groundwater flow and water quality sampling
Frequency:	Continuous- salinity, Other (Please specify): initially intensive organismal wet season and dry season, weekly for 2 months. Then monthly for 2 years, then possibly quarterly if nothing unusual
Timing:	Wet and Dry season
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Park-wide, Site Specific
Scale of Analysis:	Multiple Parks, Park-wide, Site Specific
Basic Assumptions:	- Benthic invertebrate community will respond to water and sediment quality
Research Needs:	Salinity stress on SF benthic invertebrates, study of nutrient effects on benthics, variation of infaunal components with physical and chemical constituents (variations associated with contaminants, eutrophication, etc) Relationship of these stresses to changes in community composition and structure

Management Goal:	Maintain water and sediment quality sufficient to minimize or prevent infaunal components indicative of degraded habitats
Threshold Target:	
Response:	
Constraints:	Benthic infaunal assemblages are specific to the desired ecotones (oligo/meso/euryhaline)
Status:	To be developed
Estimated Cost:	
References:	

GG. *Exploited Inverts (Lobster, Conch, Crabs, Shrimp, Stone Crab, Blue Crab, Clams, Oysters, Sponges, Welks)*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Exploited Inverts (Lobster, Conch, Crabs, Shrimp, Stone Crab, Blue Crab, Clams, Oysters, Sponges, Welks)
Monitoring Question(s):	Are the range of goals (human uses and preferred ecological states) sustainable? How do invertebrate populations change over time between and within parks?
Justification:	The exploited invertebrate assemblage include herbivores, filter feeders, intermediate feeders, omnivores. These species are under heavy fishing pressure and commercial harvest pressure within and outside SFCN parks boundaries. These species have complicated reproductive cycles that frequently use multiple habitats inside and outside park boundaries and can be affected by regional connectivity and stressors. They are sensitive to fishing pressure and environmental degradation. Balancing resource extraction with sustainability is a key management concern. The impacts of fishery management tools such as "no-take" zones are of high interest to resource management and the public.
Metric:	What is the spatial distribution of the invert population (abundance, size, species)?
Method:	Fishery dependent- monitoring recreational and commercial catch Fishery independent- visual census, acoustics, optics, nets, trawls, traps, Measure size of shells for Welks
Frequency:	Annual to quarterly
Timing:	Depending on seasonal spatial distribution.
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks), Other (Please specify): Network Wide
Scale of Analysis:	Park-wide, Site Specific: Habitat wide, Network Wide
Basic	Independence or linkage

Assumptions:	Monitoring reflects the population- appropriate timing and methodology
Research Needs:	NA
Management Goal:	Invert population stability and diversity across exploited species Sustainable fishing and other recreation
Threshold Target:	Approx. 2 standard deviations off the mean.
Response:	Reduce impacts of principal stressors (extraction): Better enforcement for Welks. Collaborate with other agencies Internal response - Close season for regulated locations.
Constraints:	Is this sampling design appropriate in predicting population estimates? [precision] Costs of high precision sampling design We know the measurement generally reflects pop changes, the level of accuracy and precision is cost dependent.
Status:	Ongoing (NOAA, FWC, NPS, Universities, etc)
Estimated Cost:	Park/Method/Intensity specific
References:	Contact: J. Bohnsack, J. Ault, J. Browder, J. Hunt, M. Robblee Welks contact Rafe.

HH. *Pink Shrimp population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Pink Shrimp population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends in pink shrimp?
Justification:	Pink shrimp (Farfantepenaeus duorarum) function as both a predatory and prey species within the marine ecosystem and provide a large amount of biomass in Florida and Biscayne Bays. They are sensitive to changes in hydrological modifications, salinity patterns, circulation effects on larval transport. Florida Bay is an important nursery ground for larval recruitment to the Dry Tortugas commercially harvested fishery. Pink shrimp are both recreationally and commercially harvested within Biscayne Bay.
Metric:	Presence/ Absence Spatial/ temporal distribution Density Size Structure Develop relationships with habitat Rates: Growth, mortality, reproduction, recruitment, immigration/emigration, secondary production, trophic level
Method:	Throw trap Trawl

	Commercial catch per unit effort
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide
Basic Assumptions:	- Consistency in sampling design and sampling methods - Consistency in protocol - Consistency of data collection and data quality control
Research Needs:	- Hydrographic dynamics and monitoring - Literature review/ research, analysis of historical data and literature to look for trophic classification by species as well as size class
Management Goal:	Productive, resilient, and sustainable populations
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Ongoing in BISC and EVER West Coast Fl
Estimated Cost:	~$250k/park/year, seasonal sampling Can be combined with fish throw trap sampling
References:	

II. *Spiny Lobster - population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Spiny Lobster - population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends of spiny lobster?
Justification:	The spiny lobster (Panulirus argus) life cycle includes both a free-swimming larval phase and a benthic adult life stage. Lobsters have complicated reproductive cycles that frequently use multiple habitats inside and outside park boundaries and can be affected by regional connectivity and stressors. Adult spiny lobsters feed mainly on gastropods, chitons, and bivalves. They are under

	heavy fishing pressure and commercial harvest pressure within and outside SFCN parks boundaries. In 2003, the commercial fishery landed over 4 million pounds in Florida.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration, secondary production, trophic level) contaminants
Method:	- Lobster pot - Commercial catch per unit effort - Visual Surveys - Pueruli collectors - larval Settlement.
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	Hydrographic dynamic monitoring for trophic classification by spp. and size class
Management Goal:	Productive, resilient, and sustainable populations
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis
Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	BISC somewhat, MINI season Visual Surveys - Buck Island Pueruli collectors - larval Settlement SeaMap Done every three years, DFW of DPNR (maybe at Buck).
Estimated Cost:	~$150k/park/year Combined?
References:	

JJ. *Oyster population structure, status, and trends*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BISC ☑ EVER

Indicator:	Oyster population structure, status, and trends
Monitoring Question(s):	What are baseline conditions, variability, and trends in oysters?
Justification:	Oysters (Crassostrea virginica) are filter feeders and become prey to many species of fish and larger invertebrates. Oysters develop into oyster bar communities which form an extensive habitat along western edge of Everglades National Park. Oysters were once present in greater numbers within Biscayne Bay, but are now rare. Oysters have a strong association with moderate saline conditions and are hence being considered an indicator of proper hydrological flows for Biscayne Bay. Their shell accumulations provide information about the physical, chemical and biological conditions that allow them to flourish.
Metric:	Presence/ absence Spatial/ temporal distribution Density Size Structure Rates (growth, mortality, reproduction, recruitment, immigration/emigration, secondary production, trophic level)
Method:	- Visual Census/ Shoreline visual survey - Tissue Sampling - Tongs - Dredge
Frequency:	Monthly- pilot project; long-term monitoring frequency to be determined, dependent on pilot
Timing:	To be determined, dependent on pilot
Scale of Collection:	Multiple Parks
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	- Consistency in sampling methods and design - protocol consistency - Consistency of data collection and data quality control
Research Needs:	Hydrographic dynamics, monitoring Contaminant Assessment
Management Goal:	Establish/ Increase population
Threshold Target:	Will be determined by baseline analysis
Response:	Will be determined by baseline analysis

Constraints:	Funding, continuous and long-term Support Skilled man power
Status:	Proposed in BISC Maybe outside Park Boundaries?
Estimated Cost:	~$150k/park/year Seasonal Surveys
References:	Mike Savasere (Fl Gulf Boast University), Jack Meter (BISC)

KK. *Marine Vertebrates - Rare, threatened, and endangered species - Crocodiles, Dolphin, Manatee, Sea Turtles, Protected marine mammals.*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Marine Vertebrates - Rare, threatened, and endangered species - Crocodiles, Dolphin, Manatee, Sea Turtles, Protected marine mammals.
Monitoring Question(s):	How do rare, threatened, and endangered species change over time between and within parks? Does the species integrity persist?
Justification:	Critically imperiled or rare marine vertebrates are typically large species that are sensitive to the effects of nesting/rearing habitat loss, habitat degradation, contaminant bioaccumulation, and food-web alterations. Recovery from historic hunting/collection pressure and low reproductive fecundity are also issues. These species are wide-ranging, experiencing a wide range of stressors and habitat quality both inside and outside park boundaries. Because of their relatively low numbers they are affected by stochastic impacts on populations such a boat collisions, entanglement in fishing gear, and entrainment in flood control structures which kill individual animals. Disturbance by visitors can also be an issue. Monitoring population status and trends and distribution is used to inform park management about the status of these legally protected species and to assess potential impacts of visitor use activities and management activities.
Metric:	What is the spatial distribution of the rare, threatened, and endangered species (abundance, size, disease, condition)?
Method:	Species dependent- Species independent- visual census, acoustics, optics, nets, trawls, traps, tagging & telemetry
Frequency:	Annual to quarterly.
Timing:	Depending on seasonal spatial distribution.
Scale of Collection:	Multi-park, some regional programs occurring
Scale of Operation:	Regional/ Network-wide
Scale of Analysis:	Network/ Park/ Habitat
Basic Assumptions:	Independence or linkage Monitoring reflects the population- appropriate timing and methodology
Research Needs:	(To better understand the sustainability of the species: Natural History/Demographics of non-exploited species)
Management Goal:	Species integrity
Threshold Target:	
Response:	Reduce impacts of principal stressors:

	Collaborate with other agencies Internal response
Constraints:	Is this sampling design appropriate in predicting population estimates? [precision] Costs of high precision sampling design We know the measurement generally reflects pop changes, the level of accuracy and precision is cost dependent.
Status:	Ongoing (NOAA, FWC, NPS, Universities, NGO's, etc)
Estimated Cost:	Park/Method/Intensity specific
References:	

LL. *Sea Turtles*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Sea Turtles
Monitoring Question(s):	Are populations of sea turtles increasing, decreasing, or stable? Is the number of sea turtle nests and nesting success increasing, decreasing, or stable? What is the status of nesting beaches?
Justification:	Four species of sea turtles nest on beaches within the South Florida / Caribbean Network of parks, all of which are either federally endangered or threatened. The most prevalent are hawksbill, green, and loggerhead sea turtles. Nesting activities on historic turtle nesting beaches reflects both the habitat quality of the nesting beaches as well as population dynamics and presumably health of both local and regional seagrass beds, coral reef areas, and oceanic areas. Sea turtles return to their natal nesting beaches to nest year after year. At least a portion of the juvenile and adult sea turtles are assumed to remain in the general area and so are affected by stressors and management within the park. Currently the greatest threats to sea turtle populations include loss of nesting beaches, degradation in quality of nesting beaches, nest predation, degradation in quality of foraging habitats (sea grass beds, coral reefs, open ocean, etc), collisions with boats, being trapped in fishing gear or trash, and disease. Artificial lighting may be an issue at Virgin Islands National Park, but is not an issue at the other parks.
Metric:	Nest counts, species which nested, distribution of nests, nesting success, nest predation Supplemental monitoring: beach erosion, sand quality, lighting, predators, and mortality will be measured/observed.
Method:	Initial beach assessment will be conducted (e.g. quality, erosion, lighting, etc.). Surveys will be conducted for nests and tracks during the nesting season (May - October). Actual nesting is verified by gently digging by hand into nest (many "false crawls" can occur). Eggs are counted. After baby turtles are assumed to have emerged, nest is re-dug and the number of empty egg-shells, live and dead trapped baby turtles, and unhatched dead eggs are counted. (Live baby turtles are released to sea). Buck Island Reef National Monument is using a more intensive protocol that might be worth exploring.
Frequency:	Annual
Timing:	During the nesting season (May - October).
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Basic Assumptions:	Monitoring numbers of nests and nesting success provides a reliable surrogate for the status of the sea turtle community. At least a portion of juvenile turtles and adult turtles remain in and around the park areas and are

	affected by local habitat quality and stressors. Any program must be done on a long term basis because we don't understand shorter-term climate cycle effects on these populations
Research Needs:	Relationship between nest counts and nesting success with juvenile and adult populations
Management Goal:	Maintain or increase populations at sustainable levels.
Threshold Target:	Insufficient knowledge. However in general any nest predation or impacts to nesting success or other problems with these highly threatened species that can be identified are typically acted upon immediately (e.g. covering nests to prevent raccoon predation).
Response:	Determine if nesting decline due to identifiable causes and attempt to correct problem (e.g. reducing nest predation, trash on beaches, artificial night lighting).
Constraints:	Sampling and searches are time consuming. Results should be interpreted in a regional as well as local context. Beaches in south Florida national parks are not the heaviest nesting beaches in south Florida and thus changes in sea turtle populations in south Florida will also reflect management at beaches outside park boundaries. Fortunately monitoring is occurring at many of these other beaches. In contrast U.S. Virgin Island national park beaches have heavy nesting within the parks. As another regional issue sea turtles are also killed in fishing nets in the open ocean far outside park boundaries.
Status:	Monitoring is on-going at Biscayne National Park, Dry Tortugas National Park, Buck Island Reef National Monument, and Virgin Islands National Park. No monitoring is occurring that we know of at Everglades National Park, although nesting does occur there. No nesting is known to occur at Salt River National Historic Park and Ecological Preserve, although beaches exist. Intensive sea turtle nest monitoring is occurring at Buck Island with nightly surveys during nesting season and measurements also taken on female size. All nesting females are tagged. A juvenile sea turtle monitoring program is also ongoing.
Estimated Cost:	
References:	Zandy Hillis-Star (Buck Island Reef National Monument), Shelby Moneysmith (Biscayne National Park), Emilie Verdon (IRC)

MM. *American crocodile (Crocodylus acutus)*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BISC ☑ EVER

Indicator:	American crocodile (Crocodylus acutus)
Monitoring Question(s):	What is the relative distribution, abundance, nesting effort and success, condition, growth and survival of crocodiles in relation to water levels and salinities throughout mangrove estuaries of Everglades National Park and Biscayne National Park? How do these metrics change over time and during Everglades restoration?
Justification:	The American crocodile is a top predator within the estuarine ecosystem. Crocodile population dynamics have been linked to resource management activities, especially water management which has resulted in increased salinities in both estuaries. Habitat alteration and conversion along western Biscayne Bay, disturbance, and road kill are also issues. Crocodiles are an Endangered Species with core nesting areas in Biscayne and Florida Bays.
Metric:	Animals/ shoreline km, Size distribution, Body condition, Annual survival, mm increase in body length, nests/region All metrics are equivalent to those used as performance standards in Comprehensive Everglades Restoration Plan (CERP).
Method:	Distribution and abundance are obtained through night-light survey along established routes throughout the Parks. Condition, growth, and survival are determined from morphometric measurements of captured and released animals encountered during quarterly surveys. Nesting effort and success are determined by inspecting nests found during ground and aerial searches. See Mazzotti and Cherkiss (2003) for justification and protocols. Protocols are also present in Crocodile MAP annual reports as well as CESI Crocodile distribution project reports.
Frequency:	Annual
Timing:	Night-light surveys and captures are currently performed quarterly. Nest searches are conducted during April-August.
Scale of Collection:	Park-wide
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Park-wide, by park region.
Basic Assumptions:	The underlying assumption of this indicator is that the distribution and abundance of crocodiles is strongly influenced by patterns of fresh water flow. All metrics assume that data collection provides estimation of detection probability (crocodile eyeshine, nests). This is accomplished through design of monitoring using distance sampling, transect methodology, and/or direct estimation of detection.
Research Needs:	Additional research is needed to reduce the uncertainty regarding the importance of fresh water for growth and survival of hatchling crocodiles.

Work is currently underway funded by CESI and MAP to address detection under the various monitoring components.

Management Goal: Restoration of location of freshwater flow will result in an increase in relative density of crocodiles in areas of restored flow, such as Taylor Slough/Taylor River drainage. Reestablishing the salinity gradient in the estuary will increase growth and survival of juvenile crocodiles throughout the estuary. All of the above will result in increased nesting.

Threshold Target: Historical data exist to provide estimates of natural annual variation. These data have not been used to set threshold targets.

Response: Habitat restoration as necessary.

Constraints: Continued priority of monitoring program.

Status: On-going.

Is an indicator in the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan (MAP) and Interim Goals.

Estimated Cost: Approximately 6 man-hours per night-light survey (6 per transect per year), 20 man-hours per body condition survey (4 per region monitored per year), About 160 hrs for nest surveys by boat and foot, supplemented by 10-20 hours helicopter time and man-hours per year for nest surveys.

References: Mazzotti, F. J., and M. S. Cherkiss. 2003. Status and conservation of the American crocodile in Florida: Recovering an endangered species while restoring an endangered ecosystem. Technical Report. 41 pp.

NN. *Marine Invertebrates - Rare, threatened, and endangered species - Acropora, Diadema, Antipathes*

Which conceptual model(s) is this indicator linked to?

☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ SARI ☑ VIIS

Indicator:	Marine Invertebrates - Rare, threatened, and endangered species - Acropora, Diadema, Antipathes
Monitoring Question(s):	How do rare, threatened, and endangered species change over time between and within parks? Does the species integrity persist?
Justification:	Critically imperiled or rare invertebrate species within the marine community are important indicators and subjects for monitoring, as they are significant drivers/architects of reef community and structure. Elkhorn coral (Acropora palmata), once the primary reef building species, has declined >95% in areas, dramatically effecting many marine and coastal processes. Black spiny sea urchins (Diadema antillarum), once abundant herbivores, have significantly reduced populations, dramatically affecting herbivory of marine algae on coral reefs and subsequent coral reef recruitment and growth processes. Black coral (Antipathes sp.) have been overharvested for jewelery to the point that they are now considered rare.
Metric:	What is the spatial distribution of the rare, threatened, and endangered species (abundance, size, species, condition)?
Method:	Species dependent- Species independent- visual census, acoustics, optics,
Frequency:	Monthly to Annual. Episodic
Timing:	Night surveys for Diadema maybe? Spawning?
Scale of Collection:	Multi-park
Scale of Operation:	Regional/ Network-wide
Scale of Analysis:	Network/ Park/ Habitat
Basic Assumptions:	Independence or linkage Monitoring reflects the population- appropriate timing and methodology
Research Needs:	Connectivity Knowledge about disease pathogens
Management Goal:	species sustainability
Threshold Target:	To be determined
Response:	Reduce impacts of principal stressors: Collaborate with other agencies Internal response
Constraints:	Is this sampling design appropriate in predicting population estimates? [precision] Costs of high precision sampling design

We know the measurement generally reflects pop changes, the level of accuracy and precision is cost dependent.
Pathogens for disease uncertain

Status: Ongoing (NOAA, USGS, FWC, NPS, Universities, NGO’s, TNC, etc)

Estimated Cost: $20K/year/park

References: Contact: C. Rogers, NOAA Status Review of Acropora,

OO. *Fire Return Interval Departure*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Fire Return Interval Departure
Monitoring Question(s):	Where upon the Landscape does a departure from native fire regimes exist?
Justification:	Fire is a major driver in vegetation community distribution, structure, and composition across the landscape. Maintaining a fire regime that mimics the historical pattern while maintaining public safety is important for maintaining such communities as the pine rocklands from being encroached by hardwood hammocks, marshes from being encroached by forests and mangroves, etc. Monitoring Fire Return Interval Departure is an important tool for assessing the health of the system with respect to this important driver as well as providing key information for fire management decisions.
Metric:	Fire Location. (Lat/Lon) Fire Size expressed in acres Perimeter in digitized shapefile Date(s) of fire event Ignition Source (lightning, human)
Method:	Assemble and historical fire records, develop GIS shape files for fire perimeter, ground truth fire locations (to determine if site is capable of supporting combustion, i.e. non-flammable vegetation-fuel conditions or standing water). Develop departure classification scheme.
Frequency:	Continuous, After each fire event
Timing:	post-fire
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Historic fire records are complete and accurate
Research Needs:	What climate patterns or cycles create conditions for landscape level fire events and when do these occur? Which fire regimes will support or enhance ecosystem restoration? What were the spatial extent of historic fire events?
Management Goal:	Use management practices that ensure ecologically appropriate fire regimes.
Threshold Target:	90% of flammable vegetation National Park Service managed landscape in South Florida receives ecologically appropriate fire treatment within a 20 year period

Response: Develop landscape level fire management goals and objectives for Everglades and Big Cypress

Constraints: The capacity and interest of the two park units to work together, share information and resources.
Access to elevation and inundation data.
Accurate historic fire records

Status: Retrieval and evaluation of historical has begun
Development of GIS based shape files is ongoing by EVER fire staff
Organization and display of data base is in development by EVER fire staff

Estimated Cost: Ground-Truthing and Mapping Flights @ 750.00 per hour, estimated cost 7500.00 per year.

Interns for data processing 20,000.00

References: SEKI has conducted similar monitoring of the Sierra landscape

PP. *Shape, orientation, location, and coverage of vegetation community types*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ DRTO ☑ EVER

Indicator:	Shape, orientation, location, and coverage of vegetation community types
Monitoring Question(s):	Spatial Patterns of vegetation in wet prairies and marshes, forests, tree islands, mangroves, beaches and tidal wetlands changing? Are these changes related to environmental drivers? Are these changes related to Everglades restoration (e.g. CERP) or other management efforts?
Justification:	The spatial patterns of vegetation in wet prairies and marshes, forests, tree islands, mangroves, beaches and tidal wetlands are expected to show changes due to management regimes (regional hydrology changes by Everglades restoration efforts; fire) as well as natural succession processes, sea level rise, and invasive species. It is important that a baseline as well as a sound monitoring program be established in order to track the impact of these changes at a regional scale. The mosaic and diversity of vegetation communities across the landscape strongly influences animal communities, food web-structure and distribution of rare plants. Such information is also useful from management planning, monitoring planning, and visitor use perspectives.
Metric:	Aerial photography and vegetation mapping of community types (classifications). Metrics: 1. Number of patches by type 2. Location of patches (e.g. mangroves shifting inland, mangrove shifting due to frost, Muhly wet prairie shifting in relation to rehydration) 3. total acreage of patches 4. Size distribution of patches a. avg.-min-max patch size, 5. shape specific to type a. orientation related to flow (wet prairies and marshes, sloughs, tree islands) b. Beach width 6. Potential for determining canopy height from stereo pairs but this may add significantly to the cost and effort
Method:	Comprehensive Everglades Restoration Plan (CERP) mapping project for vegetation methodology for landscape level coverage. Tree Island shape studies from Loxahatchee, see Laura Brandt. This mapping would be done using the CERP mapping aerial imagery but would not be the same product as the CERP mapping effort. This project would require finer scale characterization of boundaries and the development of polygons instead of the CERP process of MMU (CERP = 50 X 50 M) classification.
Frequency:	Every 4-6 years (CERP mapping program frequency), Additional sampling should occur within the event boundary in response to large scale disturbance events such as frosts, hurricanes, large fire events (e.g. 100,000 acres), floods, etc.
Timing:	In concert with existing aerial photo programs (CERP, etc.) for use of existing imagery. As imagery

	is available since time-lags between acquiring images and interpreting images can make accurate determinations more difficult if not impossible.
Scale of Collection:	Same as CERP mapping boundaries: includes EVER, BICY, but DRTO and BISC are not included in CERP mapping effort at this time. All wet prairies, marshes, sloughs, mangroves and tidal wetlands are included. Tidal Creeks are a RECOVER indicator. Consider tidal creeks because an additional indicator for tidal creeks may be developed separately - either include tidal creeks here or develop this concept for tidal creeks elsewhere.
Scale of Operation:	Regional (incl. areas outside parks), Some events operate at a more local scale
Scale of Analysis:	Multiple scales including all the above
Basic Assumptions:	Vegetation patterns reflect environmental drivers and patterning and changes in management. In turn, vegetation patterns drive other environmental factors such as wildlife populations. This indicator looks at the biotic response to drivers; it does not monitor specific drivers (different drivers would elicit different changes), however, the correlations in relation to changes in vegetation pattern need to be able to be established from other monitoring efforts (e.g. hydrology, nutrients, etc.)
Research Needs:	An understanding of historical or existing conditions to be able detect and determine changes. Determining whether CERP classification is capable of identifying specific community classes of special interest such as Schizycharium vs. Muhlenbergia vs. Cladium vs. Eleocharis vs. etc. If CERP mapping effort cannot distinguish this level of type differences then the imagery would have to be used to reclassify polygons for this map product.
Management Goal:	Trend toward decrease in sawgrass and increase in wet prairie and slough without a loss in total diversity of community types and sustained current levels of biodiversity. Mangroves, beaches and tidal wetlands should show little to no inland movement or change in areal extent.
Threshold Target:	Insufficient knowledge, however, once these data are established prior to dramatic hydrologic changes the target would be a sustained level of biodiversity with no loss of any vegetation type. Threshold targets may not be practicable for this indicator until trends in patterns are developed for different eco-regions that are being affected or not, by different management regimen (e.g. fire, water, etc.). Targets would be different for different vegetation types (e.g. mangroves, wet prairies, etc).
Response:	Management responses would depend on management actions and the resultant effects of those actions on the vegetation patterns. For example, changes in fire management in coastal marshes may alter marsh vegetation patterns. A determination of the "relevance" of the change in the pattern and any subsequent change in management actions would be needed (i.e. more research?).
Constraints:	Limitations of aerial photo being able to be used to resolve the different vegetation types and boundaries between types. This includes resolution and scale. If boundaries between marsh and slough areas cannot be delineated from the imagery (e.g. Shark Slough vs. wet prairie), it may be necessary to delineate vegetation types and boundaries within a single large bioregion or Conceptual Ecological Models (e.g. Wet Prairies and Marshes).
Status:	Comprehensive Everglades Restoration Plan / RECOVER is currently creating a vegetation map of CERP-related areas of EVER, BICY, BISC, and the Water Conservation Areas using 1:24000 Color-Infrared Photography. Remapping is currently scheduled every 5 years. (See Ken Rutchey, SFWMD) NPS-South Florida / Caribbean Network is mapping the remaining areas of BICY and EVER not covered by the CERP effort with a consistent methodology. This is a one-time mapping effort to create a baseline vegetation map.
Estimated Cost:	Ken Rutchey (SFWMD) has estimated costs for interpretation on a per acre cost.
References:	Ken Rutchey and Kevin Whelan (NPS)

QQ. *Ecotone shifts along wetland boundaries - Mangrove to marsh to cypress- Aerial photography*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Mangroves
☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Ecotone shifts along wetland boundaries - Mangrove to marsh to cypress- Aerial photography
Monitoring Question(s):	Are the wetland ecotones changing in aerial size (becoming wider or narrower)? What is the influence of CERP and land use change in EVER, BICY and BISC on ecotones? What are the effects of sea-level rise on ecotones?
Justification:	Tracking the position of mangrove-marsh and mangrove-marsh-cypress ecotones can indicate the long-term trajectory of the wetland ecosystem especially in regards to the ecological forcing from regional water management changes and sea-level rise. This regional process can be effectively monitored by aerial photography. In South Florida at selected sentinel sites, the movement of the ecotone across the landscape historically has been an important indicator of water management, e.g. "White Zone" in southeast Everglades.
Metric:	Track and ground-truth aerial change and movement of ecotone across the landscape at selected sentinel sites, historically and over time (e.g. 10 year intervals). Measure change in area of features, e.g. "White Zone" in southeast Everglades. Units of change would be area (ha) and direction
Method:	Comparison of sequential, geo-referenced, and ground-truthed aerial photographs
Frequency:	Every 3-10 years (approximate interval) depending in part on speed of change
Timing:	Anytime that cloud cover is low and vegetation can be delineated
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Note: consider including partner DOI and State of Florida landholdings (e.g., Ten Thousands Islands NWR; Florida Panther NWR; Fakahatchee Strand State Park)
Basic Assumptions:	Sample assumption is that ecotones can be demarcated well with chrono-repetitive aerial photographs (i.e., area change is great enough to detect differences relative to sampling variation) Method assumption is that shifting ecotones in multiple directions are good indicators of long-term change
Research Needs:	Monitor bi-directional past changes in wetland community shifts from cypress swamps (BICY & EVER) to marsh (BICY & EVER) to mangrove (EVER & BISC). Relate to shifts to hydrological manipulations, fire incidence, or elevation loss/gain.
Management Goal:	Determine if ecotone is shifting towards coast as CERP is implemented, or how ecotone is shifting with "natural" hydrological changes associated with climate (e.g., sea-level rise, temperature, fire, freeze, etc....) or hurricanes.
Threshold	Insufficient knowledge

Target:	
Response:	Identify constrictions to water flow and modify hydrologic releases patterns
Constraints:	There are several "types of mangrove: non-mangrove wetland ecotones- mangroves with a) periphyton-spikerush, b) sawgrass, c)needlerush, d) spartina, e)succulents (botis, seguvium)- and then each of these with cypress - these may respond differently. Determining cypress versus mangrove coverage from aerial photographs in areas of habitat overlap (principally BICY & EVER), especially along dendritic channels (rivulets) in the region can be challenging if the sampling protocol stipulates limited funds for ground-truthing.
Status:	The USGS has mapped mangrove-to-ecotone shifts in EVER from 1927 through at least 1995 (Tom Smith & Ann Foster - USGS-FISC; Tom Doyle - USGS-NWRC). USGS has been conducting the EVER Historical Air Photo project (EHAP), scanning old air photos. Need to develop GIS layers. "White Zone" has been mapped on one occasion. Cypress-to-marsh habitats have been largely ignored as a temporal component of mapping efforts. Ecotone mapping has been useful at verifying systems landscape models for predicting shifts and sensitive elements of shifts in EVER (contact Tom Doyle - USGS-NWRC, 337-266-8647). There is also a strong desire from the larger scientific community to expand our understanding of which drivers are most responsible for dictating ecotonal dynamics through the use of landscape ecological simulation models. In other words, consider linking mapping efforts with modeling efforts for individual parks.
Estimated Cost:	Approximately $100-$120 K per year for at least a two-to-three-year focal period every 10 years, for example. Budget would have to include salary, travel, and photo acquisition costs for a GIS Specialist. Project costs would be lower if NPS has a GIS Specialist on permanent salary; overall program costs, of course, remain the same. Costs exclude modeling efforts
References:	Contact Tom Smith and Tom Doyle, See Smith et al (2002), Open-file Report 02-207, Open-file Report 02-236, on sofia.usgs.gov

RR. *Location of critical ecotones - field plots/transects*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Location of critical ecotones - field plots/transects
Monitoring Question(s):	Are ecotones shifting due to physical conditions e.g. Hydrology, climate change, anthropogenic factors, sea level rise, fire, episodic metrological and storm wave events etc.
Justification:	Ecotones are transition zones between habitats and are generally dynamic locations for flora and fauna. Due to the sharp transition between habitats, tracking the position of ecotones can indicate the long-term trajectory of the habitats. Understanding the physical conditions which are driving the change in the ecotone location will be critical for proper resource management. Examples of

	ecotones include mangrove-tidal marsh ecotones; tidal wetlands (mangrove/tidal marsh)-freshwater marsh ecotones; sawgrass ridge-slough-tree island ecotones; marl prairie-sawgrass marsh ecotones; pine-marl prairie ecotones. Ecotones are expected to move, for example, in response to changes in water management, sea level rise, and fire management.
Metric:	Species composition and physical structure of vegetative community or habitat.
Method:	Transects/plots from one ecosystem to another. Possible overlap with CERP marl prairie to slough methodology and other existing monitoring. St. John program - beach profile
Frequency:	Every 3-5 years, VIIS quarterly for beach program.
Timing:	Varies by logistics, but same time each sampling period once initiated. Need to be able to respond rapidly to an "event"- a hurricane, fire, flood
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Park-wide
Basic Assumptions:	Ecotones move in response to changes in environment. Ecotone shifts reflect changes in environment.
Research Needs:	
Management Goal:	Changes in ecotones will occur via natural means. Non-natural, controllable changes will be minimized.
Threshold Target:	Varies by community, but any shifts thought to be due to non-natural events will be reported to management.
Response:	Determine if change in ecotone is due to non-natural process. Minimize influence of non-natural process, if possible, e.g. change fire regime, restore hydrological patterns, and control exotic and undesirable native vegetation.
Constraints:	Monitoring unconstrained.
Status:	Some monitoring ongoing (vegetation mapping, transects in pine-prairie ecotones, transects in prairie-slough (CERP), CSSS work may apply, Raccoon point monitoring may apply, BISC and BICY inventory work may apply, ground truthing in ENP and BICY may apply. VIIS beach profile program (Rafe), Salt River site specific monitoring.
Estimated Cost:	Determined by chosen methodology, location. Estimated $60,000/sampling period for each unit.
References:	Resource management staff at related park units, USGS staff, university staff, local non-profits.

SS. *Location of Hammock-Pineland ecotone - field plots/transects*

Which conceptual model(s) is this indicator linked to?

☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Location of Hammock-Pineland ecotone - field plots/transects
Monitoring Question(s):	Are ecotones between pineland and hammock shifting due to physical conditions, e.g. fire, hydrology, climate change, anthropogenic factors, sea level rise, etc.
Justification:	Both hammocks and pinelands (esp. pine rocklands) are important habitats for rare and endemic plant species and for wildlife, with different species occurring in each. Hammocks are spatially limited vegetation community occurring within a matrix of pinelands in south Florida. Pinelands are fire adapted whereas hammock species are less so. In the absence of fire, hammock species expand into pinelands. However fire can reduce or even eliminate hammocks. Thus appropriate fire management is critical to maintaining a balance of both these habitats. Invasive species could also impact these relationships. Long-term monitoring will detect changes in the position of the ecotone allowing management changes to be made if necessary.
Metric:	Plant species composition, physical structure of vegetative community (canopy height; density at different strata), soil depth to and including A horizon and O horizon
Method:	Transects/plots from hammock to pineland. Permanent plots will be established along a belt transect which runs across the ecotone and into mature portions of each community. In each plot the following data will be recorded: Canopy height, vegetative cover of each plant species, canopy cover in each stratum (canopy, herb layer, shrub layer, etc), O horizon depth, and A horizon depth. Data will be analyzed to determine if species composition, soils, and vegetation structure are changing along transects over time.
Frequency:	Every 3-5 years
Timing:	Same time each sampling period once initiated. Timing not critical.
Scale of Collection:	Multiple Parks
Scale of Operation:	Multiple Parks, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Hammock-pineland ecotones shift in response to environmental changes, especially hydrology and fire conditions (seasonality, and intensity).
Research Needs:	Identification of baseline or reference condition from aerial photography. Coordination with burn monitoring programs necessary. Information on management decisions that identify how systems should be maintained. Information on concurrent hydrological changes in study areas.
Management Goal:	Maintain an appropriate balance of pinelands and hammocks in healthy condition across the landscape and conservation of rare and endemic species within them.
Threshold Target:	Any shifts thought to be due to non-natural events will be reported to management.
Response:	Determine if change in ecotone is due to non-natural process. Minimize influence of non-natural

process, if possible. e.g. Change fire regime, restore hydrological patterns, control exotic and undesirable native vegetation.

Constraints:	Monitoring unconstrained.
Status:	No current monitoring known within parks specific to this issue, but Raccoon Point monitoring data may be applicable.
Estimated Cost:	Estimated $20,000-40,000/sampling period for each unit.
References:	Resource management staff at related park units, USGS staff, university staff, local non-profits.

TT.*Physical drivers of mangrove-marsh ecotone*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves

Parks where monitoring would be conducted

☑ BISC ☑ EVER

Indicator:	Physical drivers of mangrove-marsh ecotone
Monitoring Question(s):	How are climate change and modifications in freshwater input impacting the coastal gradient?
Justification:	There is a sharp transition between the mangrove-marsh ecotone which maybe a result of the interaction of freeze/fire events and sea level rise/ water management. Tracking the position of mangrove-marsh ecotones can indicate the long-term trajectory of the mangrove ecosystem especially in regards to the ecological forcing from regional water management and sea-level rise. However, to properly interpret mangrove-marsh ecotonal movement, porewater salinity monitoring to show how the salinity gradient is changing coupled with accounting for rare freeze/fire events is necessary in addition to aerial photography.
Metric:	1. Porewater salinity across this gradient 2. Winter low temperatures across this gradient 3. Low-level photography to assess concurrent shift in vegetation with ground-truthing
Method:	See Metric above; Across spatial networks, I-button temperature sensors, salinity in distilling wells
Frequency:	Salinity & temperature continuously; vegetation every 3 years
Timing:	See above
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Basic Assumptions:	If salinity & winter freezes didn't affect encroachment of mangroves
Research Needs:	1. modeling of porewater salinity with salinity in adjacent marine waters 2. salinity & freeze stress response of major plant species 3. characterize species variability in microclimate in landscape
Management Goal:	Mitigate continued encroachment of mangroves as much as possible
Threshold	Insufficient knowledge

Target:	
Response:	N/A
Constraints:	Other drivers may be important in some locales
Status:	TIME modeling addresses coastal marshes to some degree. Ongoing salinity monitoring programs in USGS are not geographically comprehensive. Existing temperature monitoring programs are not adequate.
Estimated Cost:	Economics of scale make this difficult to estimate
References:	Tom Smith, Mike Ross, Robert Twilley, Victor Rivera-Monsoy, Gordon Anderson, Kevin Whelan

UU. *Long-term, within-community vegetation shifts using permanent plots*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Long-term, within-community vegetation shifts using permanent plots
Monitoring Question(s):	Are there changes in plant community dominant species, structure, composition, and quality over time within communities (e.g. forest, marsh, mangroves)?
Justification:	Plants are important primary producers and dominant physical structure components in terrestrial natural systems. They are the quintessential primary focus component of almost all natural land resource management agencies. Long-term, within community changes in vegetation community composition and structure provides important information for management and may indicate transformation of successional state, time since disturbance, eutrophication, hydro-pattern (including groundwater), water quality, fire regime, disease or insect outbreak effects, changes in relative cover by native/non-native species (etc).
Metric:	Species composition in multiple strata, percent cover (native and exotic), density, species richness. In forested areas, forest inventory (e.g., basal area, height, tree density), including overstory and understory composition, assessment of regeneration, presence and cover of exotic plants, and herbaceous plant surveys within fixed plots. [Soil depth, type and simple soil nutrients could be measured at the same time.]
Method:	Establish permanent, fixed radius (e.g., 13 m radius) or fixed-edge (e.g., 20 x 50 m) plots from which plant community structure is monitored with established protocols periodically. Established protocols will include main plots, sub-plots, and smaller plots of herbaceous vegetation and regeneration. Attributes to monitor will include tree DBH, tree height, herbaceous plant coverage, seedling density, soil depth, soil type, and soil nutrients. Note: these should not be confused with ecotone questions or belt transect techniques. Those techniques are structured to determine fundamentally different things.
Frequency:	Every 3-10 years (approximate interval), Other (Please specify): Longer frequency in forested habitats (5-10 years). Shorter frequency in herbaceous habitats (3-5 years). Additional sampling following catastrophic events such as hurricanes, intense fires, hydrologic alteration.
Timing:	Late dry season or early wet season for the wetlands, but timing may be driven more by access (e.g., airboats, lack of mosquitoes for mangroves) than plant phenology.

	Same time each sampling period once initiated. Initiation of sampling in some communities (e.g. Fire dependent) may require a specific season. Cloud cover should be low so that vegetation can be delineated
Scale of Collection:	Multiple Parks, Site Specific, community specific
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Site Specific, community specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, community specific
Basic Assumptions:	Plots will be located by protocol to facilitate identifying its exact location along 10 year sample intervals, for example, even after hurricane disturbance or lightning damage. Techniques should include GPS locations to identify general areas, but must include witness trees and establishment of plot centers/plot corners to ID exact plot boundaries. Location of plots are representative of the larger community and indicate habitat change, especially in reference to loss of dominant species and colonization by invasive plants. Plant species composition both responds to environmental drivers and in turn drives other species responses at smaller changes than conversion between vegetation types (e.g., cape sable seaside sparrow populations respond to Muhlenbergia density).
Research Needs:	Identification of existing baseline data. Identification of communities most likely to reflect changes in the ecology of the system. Calibration of individual species responses to hydrology, soil type and soil nutrients. Determine how vegetation communities are persisting over time in light of their individual stress gradients. All parks will be influenced by hurricanes and sea-level rise, while only a few will be influenced by human-mediated hydrologic changes, for example.
Management Goal:	Maintain structure and regeneration patterns found in the initial survey (??), with the understanding that the initial structure surveyed may not be a climax association or the best indicator of historic habitat. Change, hence, may be rated as good, bad, or neutral through this documentation process. Determine method of establishing appropriate community structure, species composition, and dominance.
Threshold Target:	Insufficient knowledge, but variation in community structural change over time is likely to be high in some communities, especially in a hurricane-prone region. Any shifts thought to be due to non-natural events will be reported to management. Background data on current conditions (e.g., REMAP) exist.
Response:	Variable. Determine if change in community structure, species composition, and dominance is due to non-natural process. Minimize influence of non-natural process, if possible. e.g.. Change fire regime, restore hydrological patterns, control exotic and undesirable native vegetation. If native dominant species are being lost, suggest plantings. If species are rare, suggest propagation programs. In general, however, the latter topic (rare plants) should be included as a separate monitoring plan.
Constraints:	Standardizing sampling techniques over time with personnel turnover and budget changes.
Status:	Permanent plots are currently located in several of the parks within the region. BICY and EVER are at least two. Raccoon Point monitoring data may be applicable. This format would, for the first time, propose an among-park permanent sampling scheme that can easily be integrated with existing permanent plots. This technique will offer an excellent way to communicate with all other I&M programs along the lines of data comparison.

Permanent plots already occurring in St. John.

Monitoring of this form has been tentatively proposed as a component of CERP landscape monitoring (Philippi 2005), although it is not currently in development.

Estimated Cost: Sampling will likely need to be staggered from year-to-year from among the parks in the I&M Network. Best guess, excluding personnel costs, $50K per annum for forest plots as a continuous allotment (assuming that permanent survey personnel are located in south Florida).

Get ballpark estimates from Mike Ross. Similar REMAP vegetation sampling cost ~$100 for soil samples plus personnel and transportation costs (helicopter, airboat).

References: Kevin Whelan (NPS), Keith Bradley (IRC), George Gann (IRC), Mike Barry (USFWS)
Philippi T. 2005. Final Report to SFWMD CP040131
Stohlgren, T. J., A. J. Owen, and M. Lee. 2000. Monitoring shifts in plant diversity in response to climate change: a method for landscapes. Biodiversity and Conservation 9:65-86.
There is a huge literature base for this, especially from the tropics. Resource management staff at related park units, USGS staff, university staff, local non-profits.

VV. *Critically Imperiled and Rare Plants:*

Which conceptual model(s) is this indicator linked to?

☑ Forest Uplands and Wetlands ☑ Island Interior

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator: Critically Imperiled and Rare Plants:

Monitoring Question(s): Are population sizes of rare plants increasing, decreasing, or stable

Justification: Critically Imperiled or Rare plant species are important indicators and subjects for monitoring for the following reasons: they will be the first plants to become extirpated if habitat quality declines; they are sensitive to changes in ecosystem processes, such as disruption of pollinator populations, or increases or decreases in hydrology; they are either endemic to the study region or are at the geographical limits of their ranges and extirpation would result in extinction or a contraction in the species' global range; and if endemic they may be host plants for other rare or endemic organisms, such as invertebrates.

Metric: Demography and distributions of each rare plant species, including annual population sizes, mortality, recruitment, and extent of habitat occupied.
Focal species:
All Critically Imperiled plants of Long Pine Key, Everglades National Park
Species of the East Everglades - Anemia wrightii, Phyla stoechadifolia, Vanilla barbellata
Species of the EVER coastal area - Cheilanthes microphylla, Chromolaena frustrata, Kosteletzkya depressa, Malachra urens, Oncidium undulatum, Pavonia paludicola, Peperomia humilis, Rhipsalis baccifera,
Species of BICY - Burmannia flava, Calopogon multiflorus, Dalea carthagenensis var. floridana, Quercus nigra, Trichomanes holopterum, Viola palmata
Species of BISC - Aristolochia pentandra, Eugenia rhombea, Guajacum sanctum, Opuntia corallicola, Pavonia paludicola, Phoradendron rubrum, Pseudophoenix sargentii, Rhynchosia

	swartzii, Vallesia antillana Species of DRTO - Cenchrus myosuroides Species of VIIS, SARI, and BUIS - to be determined
Method:	Areas with rare plant populations will be surveyed on foot. The extent of habitat occupied by each rare plant species will be mapped. Individuals of each rare plant will be tagged and mapped. For each individual several attributes will be recorded, including plant size (e.g. height, canopy diameter), flowering and fruiting activity, life history stage (e.g. seedling, juvenile, reproductive adult). Plants will be monitored annually to track long term changes in population numbers and extent.
Frequency:	Annual, every 3-5 years, Species specific - depending on life history. Trees may be monitored less frequently than herbs.
Timing:	Species specific
Scale of Collection:	Multiple Parks, Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Basic Assumptions:	Any program must be done on a long term because we don't understand shorter-term climate cycle effects on populations
Research Needs:	Data mining for baseline data on species occurrences
Management Goal:	Maintain populations at sustainable levels
Threshold Target:	Long term populations need to be stable or increasing
Response:	Determine if population decline is due to anthropogenic causes or other and utilize adaptive management to correct problem (e.g. change fire, hydrology, or augment population sizes)
Constraints:	Demographic sampling is time consuming
Status:	A five year monitoring program of critically imperiled plants of Long Pine Key, Everglades National Park is in its third year.
Estimated Cost:	$5K -20k per species per sampling year
References:	Jimi Sadle (BICY), Keith Bradley (IRC), George Gann (IRC), Emilie Verdon (IRC), Craig Smith (EVER), Tom Phillipi (FIU), Andrea Atkinson for sampling design issues (NPS-SFCN), Jim Burch (BICY)

WW. *Periphyton*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Mangroves
☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Periphyton
Monitoring Question(s):	Is periphyton cover, distribution, biomass, productivity and composition changing in response to alterations in water quality, hydrology and related habitat changes?
Justification:	Periphyton is a critical primary producer base of the food web in South Florida wetlands and estuarine areas. Periphyton production can exceed phytoplankton; it stabilizes the sediments, controls nutrient upwelling, and changes compositionally in direct response to salinity and water management (quality, quantity, timing, duration).
Metric:	Aerial Cover Structure Biomass Productivity Organic/Inorganic (Calcite) content Nutrient content Species composition
Method:	Aerial Cover - photographs of fixed quadrats (m2) and aerial image analysis (km2) Structure - substrate-specific cover estimates (benthic, epiphytic, metaphytic) Biomass - dry weight, ash-free dry weight and chlorophyll a scaled to m2 using cover estimates Productivity - on a subset of sites by BOD incubation Organic/Inorganic (Calcite) content - ratio of ash-free dry mass to dry mass Nutrient content - total phosphorus (nitrogen and carbon) per gram dry mass Species composition - relative abundances of algal taxa
Frequency:	Annual
Timing:	Samples should be collected in the late wet season (August-November) and from a sub-set of sites during the dry season (Feb-April).
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Regional (incl. areas outside parks), Site Specific
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	Periphyton responds in structure, productivity and composition to habitat alterations.
Research Needs:	1. Can periphyton be investigated at the landscape-scale through aerial image analysis? 2. How do short-term disturbance events (hurricanes, fire, prolonged drought) affect periphyton response to longer-term changes?
Management Goal:	1. Ridge and Slough - restoring ridge and slough topography will increase contrast in periphyton abundance between the two habitat types (high in slough, low in ridge). Increased water depth will

shift mats to the water column (metaphyton) and increase the organic and TP content, green algae and diatoms. Inherent increased nutrient delivery will shift these qualities further in the same direction but may also decrease overall biomass.
2. Marl Prairie/Rocky Glades - increased hydroperiod in the severely dry end of this gradient will increase periphyton production while lengthening beyond 365 days will reduce it. There may be a shift to increasing metaphyton production (relative to benthic and epiphytic), increased organic and TP content, green algae and diatoms. Inherent increased nutrient delivery will shift these qualities further in the same direction but may also decrease overall biomass.
3. Estuaries - altered freshwater and nutrient delivery to the coastal zone will radically shift composition of periphyton communities.

Threshold Target:
1. Ridge and Slough (except LNWR)
Cover - mean 60-100 %
Structure - metaphytic > epiphytic > benthic
Dry Biomass - mean 100-1000 dry g/m2
Percent Calcite - mean 30-70%
TP Content - mean 100-200 ug/g dry mass
Composition - by multivariate analysis of difference over time
Productivity - insufficient knowledge
2. Marl Prairie/Rocky Glades
Cover - mean 70-100%
Structure - epiphytic > benthic > metaphytic
Dry Biomass - mean 800-1500 dry g/m2
Percent Calcite - mean 60-80%
TP Content - mean 100-150 ug/g dry mass
Composition - by multivariate analysis of difference over time
Productivity - insufficient knowledge
3. Estuaries
Cover - mean 0-50%
Structure - epiphytic > benthic > metaphytic
Dry Biomass - mean 100-1000 dry g/m2
Percent Calcite - mean 50-90%
TP Content - mean 100-200 ug/g dry mass
Composition - by multivariate analysis of difference over time
Productivity - insufficient knowledge

Response:
1. Examination of time series of change at site (did excedence values follow extreme disturbance event?)
2. Abatement of nutrient loading
3. Increased clean freshwater delivery

Constraints: Periphyton needs to be monitored on appropriate spatial scale to detect change over time, and sampling needs to coincide with consumer, plant and water quality monitoring to address effects of correlated variables.

Status:
1. Periphyton is being monitored at a large scale in the MAP in conjunction with invertebrate and fish collections (food web component).
2. The current MAP food web project does not sample dry habitats and therefore severely under-represents the marl prairie/rocky glades.
3. There is no continuous monitoring of periphyton in the estuary/coastal zone of Biscayne or Florida bays even though periphyton production exceeds phytoplankton there, stabilizes the sediments and controls nutrient upwelling, and changes compositionally in direct response to salinity.

Estimated Cost: $100,000 per year per 100 sites

References: Evelyn Gaiser

Davis, S. M., W. F. Loftus, E. E. Gaiser and A. E. Huffman. 2006. Southern marl prairies conceptual ecological model. Wetlands 25: 821-831

Gaiser, E. E., J. H. Richards, J. C. Trexler, R. D. Jones and D. L. Childers. 2006. Periphyton responses to eutrophication in the Florida Everglades: Cross-system patterns of structural and compositional change. Limnology and Oceanography 51: 617-630.

XX. *Freshwater fish and large macro-invertebrates in wet prairies and marshes*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Freshwater fish and large macro-invertebrates in wet prairies and marshes
Monitoring Question(s):	What are the status and trends in community composition, abundance, size structure, and distribution of fish and large macro-invertebrate assemblages in the wet prairies and marshes?
Justification:	Regional populations of wet prairies and marsh fishes and other aquatic fauna reflect regional hydrology (water depth, timing, duration, quantity, quality) and in turn are the prey base for wading birds and other higher consumers in the Greater Everglades and Big Cypress ecosystem. Water diversions and altered water management practices have resulted in declines in regional populations of fish and aquatic invertebrates with cascading impacts on higher food web levels. The Comprehensive Everglades Restoration Plan will be rehabilitating system hydrology and is expected to affect these populations.
Metric:	Community composition, Abundance (density and relative abundance), size structure
Method:	Throw traps in sparse vegetation habitats such as wet prairies. Not a proven method in thick vegetation (ie. Sawgrass) or karst topography (ie. Rocky Glades). Qualitative sampling gear in addition to quantitative methods to increase number of species collected.
Frequency:	Multiple samples that emphasize important seasonal dynamics.
Timing:	
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Multiple Parks
Scale of Analysis:	Multiple Parks
Basic Assumptions:	Sampling biases associated with each collection gear. Throw trap valid only for small fishes (<80mm) and large macroinverterates (e.g.. crayfish, prawns, dragonflies). Qualitative sampling gear collections may not represent actual abundances.
Research Needs:	Sampling efficiency in forested and short hydroperiod karst wetlands. Partitioning effect of nutrient additions and hydroperiod.
Management Goal:	
Threshold Target:	
Response:	

Constraints:

Status: On-going:
CERP-MAP (Trexler: throw trap); EVER long-term sites (Kline and Trexler: throw trap); CESI (Kline: throw trap and minnow trap; Loftus: minnow traps, minnow trap arrays, and throw traps); LTER (Trexler: Throw trap); REMAP (Trexler: throw trap)

NOTE: The Comprehensive Everglades Restoration Plan (CERP) and has "Aquatic Fauna Regional Populations in Everglades Wetlands" and "System-Wide Wading Bird Nesting Patterns" as CERP Interim Goals Indicators and monitoring variables in the CERP Monitoring and Assessment Plan.

Estimated Cost:

References: See "Status" above.

YY. *Aquatic invertebrates in wet prairies and marshes*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Aquatic invertebrates in wet prairies and marshes
Monitoring Question(s):	What shifts are occurring in aquatic invertebrate community composition and structure as indicators of hydrological patterns and water quality in the wet prairies and marshes?
Justification:	Aquatic invertebrate communities reflect water quality and hydrology (water depth, timing, duration, quantity) and are frequently used in indices (i.e. Macroinvertebrate Biological Integrity Index (MBI)) as early warning response indicators of change. These invertebrates in turn are the prey base for fish, large macro-invertebrates (e.g. crayfish), herpetofauna, and wading birds in the Greater Everglades and Big Cypress ecosystem. Water diversions and altered water management practices have resulted in changes in aquatic invertebrate community composition and abundance. The Comprehensive Everglades Restoration Plan will be rehabilitating system hydrology and water quality which should in turn affect aquatic invertebrate communities and consequently higher trophic levels.
Metric:	Community composition, Abundance (density and relative abundance) these are incorporated in the Macroinvertebrate Biological Integrity Index (MBI) SEE Pinar
Method:	Dip net, Benthic cores (note expensive), Funnel Traps Rick Jacbson Midget Pupal Exuvia - USGS contractor. Ryan King - Invert work in WCA's Turner and Trexler (Inverts in Marshes)
Frequency:	Multiple samples that emphasize important seasonal dynamics.
Timing:	Biannual Wet and Dry season
Scale of Collection:	Regional
Scale of Operation:	Regional, Multiple Parks
Scale of Analysis:	Regional, Multiple Parks
Basic Assumptions:	Sampling biases associated with each collection gear. Development of MBI for these marshes specifically / regionally. Qualitative sampling gear collections may not represent actual abundances.
Research Needs:	Development of MBI for these marshes specifically / regionally MBI may differ among habitats. Partitioning effect of nutrient additions and hydroperiod.

Management Goal:	
Threshold Target:	insufficient knowledge
Response:	insufficient knowledge
Constraints:	Requires massive collaboration across the following institutions SFWMD, DEP, Joel Trexler's CESI IOP assessment project.
Status:	On-going: CESI-IOP (Trexler: throw trap and DIP net); SWFMD (research on invertebrates - Robert Shoufford in Marsh Ecology Everglades Division) DEP (Northern Marshes Fraidomburg, Greg Graves)
Estimated Cost:	Expensive to unknown
References:	CESI-IOP (Trexler: throw trap and DIP net); SWFMD (research on invertebrates - Robert Shoufford in Marsh Ecology Everglades Division) DEP (Northern Marshes Fraidomburg, Greg Graves)

ZZ.*Butterflies*

Which conceptual model(s) is this indicator linked to?

☑ Forest Uplands and Wetlands ☑ Island Interior

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Butterflies
Monitoring Question(s):	What are the status and trends in abundance and distribution of butterflies?
Justification:	Butterflies are important pollinators that reflect changes in plant communities, caterpillar host plants, butterfly nectar plants, and pesticide use. Schaus Swallowtail (Papilio aristodemus ponceanus) and the Miami blue butterfly (Hermiargus thomasi benthunebakeri) in south Florida parks are federally listed (former) or candidates for listing (later). Information could also be useful in directing park mosquito control activities in areas of rare butterflies.
Metric:	Population abundance and distribution
Method:	Visual surveys, mark-recapture
Frequency:	Monthly
Timing:	Each month, annually
Scale of Collection:	Multiple Parks
Scale of Operation:	Site Specific, Regional (incl. areas outside parks)
Scale of Analysis:	Park-wide
Basic Assumptions:	Stressors that cause changes in plant communities influence butterfly populations
Research Needs:	Better understanding of causes of population declines for rare endemic butterflies Relationship of fire management and abundance and distribution of butterflies Metapopulation dynamics of butterflies
Management Goal:	Maintain or increase butterfly population levels Prevent extirpation of rare butterflies
Threshold Target:	Self-sustaining populations of butterfly species
Response:	Reduce pesticide spraying in the parks to avoid killing rare butterfly species
Constraints:	Social and political restraints related to pesticide spraying
Status:	EVER staff and volunteers are currently monitoring butterflies using visual surveys EVER biological and Fire staff are monitoring affects of fire on host and nectaring plants
Estimated Cost:	Travel cost and technician salary
References:	Consult Sue Perry (NPS), Ricardo Zambrano (FFWCC), Cindy Schulz (USFWS)

AAA. *Island Insects*

Which conceptual model(s) is this indicator linked to?

☑ Island Interior ☑ Mangroves

Parks where monitoring would be conducted

☑ BISC ☑ BUIS ☑ DRTO ☑ SARI ☑ VIIS

Indicator:	Island Insects
Monitoring Question(s):	What is the composition and distribution of major insect groups? e.g. beetles, pollinators. What invasive species are present and what is their distribution?
Justification:	Small islands have very simple food webs compared with mainland areas or large islands (e.g. Puerto Rico). It is assumed that insects are important in these island communities, e.g. beetles are important to nutrient recycling and as prey base; bees are susceptible to invasive species; etc.
Metric:	To be determined
Method:	To be determined
Frequency:	
Timing:	To be determined
Scale of Collection:	Multiple Parks, Site Specific
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Multiple Parks, Site Specific
Basic Assumptions:	Insects are important in these island communities e.g. beetles are important to nutrient recycling and as prey base. Bees are susceptible to invasive species.
Research Needs:	Comprehensive inventory. Requires research first to determine what species are critical to maintain ecosystem function? E.g. beetles, pollinators
Management Goal:	
Threshold Target:	
Response:	
Constraints:	
Status:	A beetle inventory was completed at Buck Island.
Estimated Cost:	
References:	

BBB. *Amphibians - USVI*

Which conceptual model(s) is this indicator linked to?

☑ Island Interior

Parks where monitoring would be conducted

☑ SARI ☑ VIIS

Indicator:	Amphibians - USVI
Monitoring Question(s):	What are the distribution and proportion of area occupied of native and non-native amphibian species at Virgin Islands National Park and Salt River National Historic Park and Ecological Preserve? What habitats are they using?
Justification:	Amphibians are an important component in the Virgin Islands terrestrial ecosystems. They comprise a large amount of the resident vertebrate biomass and generally are a strong intermediate link in the food web. Amphibians have been used as a biological indicator for many environmental variables and are sensitive to changes in breeding habitat quality, invasive species, and contaminants.
Metric:	Proportion of area occupied
Method:	Visual encounter surveys and vocalization surveys coupled with proportion of area occupied (PAO) analysis. A protocol developed by Kenneth G. Rice et al (2005) of USGS may be suitable.
Frequency:	2-3 visits per sampling year to estimate occupancy. Initially sample ever year for first 4-5 years to create baseline, then reduce frequency to once every 1-5 years as appropriate depending on data variability.
Timing:	To be determined
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Park-wide
Basic Assumptions:	The protocol developed by USGS is biased towards areas along roads and trails. Either the protocol will need to be adapted to assess amphibian populations across the park or park managers must be willing to accept that the inference will only be for populations along roads and trails.
Research Needs:	Is the Puerto Rican crested toad, Bufo lemur present on the island? It was not found during the USGS inventory and only known from one previous sighting with no voucher in existence. What are the optimum sampling times during the years and level of sampling effort required to appropriately sample this community?
Management Goal:	Reduction or elimination of introduced species. Sustainable maintenance of native populations.
Threshold Target:	Insufficient knowledge.
Response:	Control of invasive species. Habitat restoration as necessary. Mitigation of sources of contaminants.
Constraints:	See assumptions.
Status:	USGS completed an inventory and pilot monitoring protocol for St. John in 2001-2003. No long-term monitoring is underway.

Estimated Cost:	
References:	Rice, Kenneth G., J. Hardin Waddle, Marquette E. Crockett, Raymond Carthy, H. Franklin Percival. 2005. Herpetofaunal Inventories of the National Parks of South Florida and the Caribbean: Volume II. Virgin Islands National Park. U.S. Geological Survey Technical Report. USGS, Florida Integrated Science Center, UF-FLREC, 3205 College Av., Ft. Lauderdale, FL 33314, USA

CCC. *Amphibians - South Florida*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Amphibians - South Florida
Monitoring Question(s):	What is the distribution and proportion of area occupied by native and non-native amphibian species at Everglades National Park, Biscayne National Park, and Big Cypress National Preserve? Are new invasions of exotic species occurring? Are local extinctions and/or colonizations of native species occurring?
Justification:	Amphibians are an important component in South Florida ecosystems. They comprise a large amount of the resident vertebrate biomass and generally are a strong intermediate link in the food web. Amphibians have been used as a biological indicator for many environmental variables and are sensitive to changes in breeding habitat quality, hydrology, invasive species, and contaminants.
Metric:	Proportion of area occupied, species presence
Method:	Visual encounter surveys and vocalization surveys coupled with proportion of area occupied (PAO) analysis. A protocol developed by Kenneth G. Rice et al (2004-2006) of USGS may be suitable.
Frequency:	12-15 visits per plot per sampling year to estimate occupancy. Sample frequency of 3-10 years as appropriate (depends on required ability to detect change).
Timing:	Spring-Fall. See Rice et al. (2004-2006) for appropriate months by Park.
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Park-wide
Basic Assumptions:	If a species is present, the models assume that detection probability is greater than 0. Also, within-year sampling is closed to local colonization and extinction.
Research Needs:	How can the individual species occupancies be combined into community-based monitoring? For example, since South Florida amphibian species are fairly ubiquitous, monitoring of relative occupancies across groups of species (communities) might result in a better monitoring tool.
Management Goal:	Reduction or elimination of introduced species. Sustainable maintenance of native populations.
Threshold Target:	Use of previously collected data could be used to obtain targets. However, this work has not been initiated.
Response:	Control of invasive species. Habitat restoration as necessary.

Constraints:	See assumptions.
Status:	USGS completed an inventory and pilot monitoring protocol for each Park during 2001-2004. No long-term monitoring is underway.
Estimated Cost:	Approximately 1 man-hour required per sample in the field, no laboratory requirements.
References:	Rice, K.G., J.H. Waddle, M.E. Crockett, B.M. Jeffrey, and H.F. Percival. 2004. Herpetofaunal inventories of the National Parks of South Florida and the Caribbean: Volume I. Everglades National Park. U.S. Geological Survey, Open-File Report 2004-1065, Fort Lauderdale, Florida. 144pp. Rice, K.G., J.H. Waddle, B. Jeffries, and H.F. Percival. 2005. Herpetofaunal Inventories of the National Parks of South Florida and the Caribbean: Volume III. Big Cypress National Preserve. USGS Open-File Report. Fort Lauderdale, FL. Rice, K.G., J.H. Waddle, B. Jeffries, and H.F. Percival. 2006. Herpetofaunal Inventories of the National Parks of South Florida and the Caribbean: Volume IV. Biscayne National Park. USGS Open-File Report. Fort Lauderdale, FL.

DDD. *Pig Frog (Rana grylio)*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Pig Frog (Rana grylio)
Monitoring Question(s):	What is the pig frog population structure in specific wetlands within Everglades National Park and Big Cypress National Preserve?
Justification:	The Pig Frog, Rana grylio, makes up a large amount of the vertebrate biomass in freshwater wetlands. They are both a prey source and a major predator. The Pig Frog life cycle (eggs and tadpoles, adults) is directly and intimately related to the marsh hydrology (immediate and moderate time period hydroperiod). Shifts in population structure are related to general wetland health and pig frogs have been shown to bioaccumulate some contaminants (e.g. mercury).
Metric:	Synoptic Population Structure sampling. Abundance (density and relative abundance)
Method:	Hand Grab sampling at night (Ugarte 2004) Large regional Scale synoptic night light surveys for abundance using double-observer methodology. The difference in detection can be calculated for different areas (Ugarte 2004).
Frequency:	Multiple samples that emphasize important seasonal dynamics.
Timing:	Biannual Wet and Dry season
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks
Scale of	Regional (incl. areas outside parks), Multiple Parks

Operation:	
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks
Basic Assumptions:	Sampling biases associated with collection may miss extremely young individual; however, this is believed to be a minimal issue from a prior study. Qualitative sampling (four nights of repeated sampling) may not represent actual abundances.
Research Needs:	pending
Management Goal:	pending
Threshold Target:	pending
Response:	Large annual variation not tied to site specific hydrological issues should be investigated.
Constraints:	None
Status:	Prior work occurred with in EVER and WCA 3 A and WCA3 B
Estimated Cost:	Moderate to inexpensive
References:	Ugarte, C. A. 2004. PhD dissertation Human impacts on Pig Frog populations in South Florida wetlands: Harvest, water management and mercury contamination. Ugarte, C. A., et al. 2005. Variation of total mercury concentrations in Pig Frogs, Rana Grylio, across the Florida Everglades, USA. Science of the Total Environment. (345) 51-59.

EEE. *Reptiles - USVI*

Which conceptual model(s) is this indicator linked to?

☑ Island Interior ☑ Mangroves

Parks where monitoring would be conducted

☑ BUIS ☑ SARI ☑ VIIS

Indicator:	Reptiles - USVI
Monitoring Question(s):	What is the distribution and proportion of area occupied by native and non-native reptile species at Virgin Islands National Park and Salt River National Historic Park and Ecological Preserve? What is the status of the Virgin Islands Tree Boa, Epicrates monensis granti, and the St. Croix Ground Lizard, Ameiva polops, if introduced to Buck Island Reef National Monument?
Justification:	Reptiles are an important top predator on the U.S. Virgin Islands. Reptiles as a group are not as transient as birds, the other top island predator; therefore, understanding the status of the island reptiles should indicate if overall terrestrial island management is appropriate for the higher trophic species. Additionally, Virgin Islands Tree Boa and the St. Croix Ground Lizard are listed species due to habitat destruction and over collection.
Metric:	Abundance or proportion of area occupied by species
Method:	Visual encounter surveys, live trapping, and/or mark/recapture. The St. Croix Ground lizard populations are estimated directly via counts in their known locations. Estimates of the Virgin

	Islands Tree Boa likewise will need special counting procedures, assuming the few remaining populations exist within NPS boundaries.
Frequency:	Monthly, Will require several sampling periods per year to estimate occupancy.
Timing:	To be determined
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	Assumption that visual encounter surveys, live trapping or other protocol provides an estimate of relative abundance or proportion of area occupied that is a reasonable surrogate for actual abundance or occupancy.
Research Needs:	What are the optimum sampling times during the years and level of sampling effort required to appropriately sample this community?
Management Goal:	Reduction or elimination of introduced species. Sustainable maintenance or increase of native population size and distribution.
Threshold Target:	To be determined.
Response:	Control of invasive species. Habitat restoration as necessary. Introduction of rare species to new locations on cays to reduce risk due to catastrophic events (hurricanes) and invasive species introductions.
Constraints:	Community monitoring will likely need a different approach from the two rare species listed.
Status:	Monitoring is underway for the St. Croix Ground Lizard and may be occurring for the Boa.
Estimated Cost:	
References:	Rice, Kenneth G., J. Hardin Waddle, Marquette E. Crockett, Raymond Carthy, H. Franklin Percival. 2005. Herpetofaunal Inventories of the National Parks of South Florida and the Caribbean: Volume II. Virgin Islands National Park. U.S. Geological Survey Technical Report. USGS, Florida Integrated Science Center, UF-FLREC, 3205 College Av., Ft. Lauderdale, FL 33314, USA U.S. Virgin Islands Department of Planning and Natural Resources Division of Fish and Wildlife. 2005. Comprehensive Wildlife Conservation Strategy for the U. S. Virgin Islands. June 1. 2005. 216 pages. URL: http://www.vifishandwildlife.com/Wildlife/05F01WildlifePlan/Part%201%20Introduction/table%20of%20contents.htm

FFF. *Florida Box Turtle, Terrapene Carolina bauri*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ EVER

Indicator:	Florida Box Turtle, Terrapene Carolina bauri
Monitoring Question(s):	What are the population status, trends and distribution of Florida Box Turtles? Are they increasing, decreasing, or stable?
Justification:	T. c. bauri is an abundant turtle in south Florida and in some cases is called the "common" box turtle. The species is long-lived and reflects long-term habitat conditions at a site and region. They are very susceptible to habitat loss and fragmentation, roadkill (cars, farm equipment, lawn-mowers), intense fires, collection as pets, and dog and cat injury and predation. They utilize a diverse selection of upland and seasonally-flooded habitats throughout the year and play a key ecological role, serving as both predators and prey, contributing to the cycling of nutrients, and acting as seed dispersers for many native plants. As an abundant species that may be on the decline, changes in the population may be a better indicator of ecosystem health than monitoring an already endangered species.
Metric:	Demography and distributions of T. c. bauri populations, including annual population sizes, population structure, mortality, recruitment, and extent of habitat occupied.
Method:	Plots will be established for monthly mark/recapture surveys to estimate population size and searches will be conducted primarily during the wet season months when box turtles are most active as well as after prescribed fires to detect mortality. Plots will be placed in freshwater prairies, marshes, forest uplands, and wetlands, preferable 3 in wetland habitat and 3 in upland habitat. In addition, box turtles will be collected by visually searching open areas, roads, leaf litter, under vegetation, and through opportunistic collecting throughout the study area. Each box turtle will be marked permanently for future identification by filing notches on the marginal scutes (Cagle, 1939). Gender will be determined by the presence (male) or absence (female) of a plastral indentation. Age is nearly impossible to determine, therefore age will be classified by carapace length as either juvenile (< 11 cm) or adult (> 11 cm) following Dodd et al. (1994). Total population size estimates, sex-ratios, minimum number of turtles known to be alive, recapture rates, apparent survival parameters, growth, and mean morphological characteristics such as carapace length and weight will be computed.
Frequency:	Annual
Timing:	During the Wet/Rainy Season when box turtles are more active and more likely to be observed (April - November). In addition, searches will be conducted immediately after prescribed burns.
Scale of Collection:	Multiple Parks, Site Specific
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Basic Assumptions:	Any program must be done on a long term basis because we don't understand shorter-term climate cycle effects on these populations
Research Needs:	Data mining for baseline data on species occurrences.
Management Goal:	Maintain populations at sustainable levels.
Threshold Target:	Long term populations need to be stable or increasing.
Response:	Determine if population decline is due to anthropogenic causes or other and utilize adaptive management to correct problem (e.g. change fire, hydrology, or augment population sizes).
Constraints:	Demographic sampling and searches are time consuming.
Status:	Monitoring is proposed.

Estimated Cost:	$6K per replicate per sampling year with 6 replicates with additional searches outside of the plot area = ~$40K per sampling year
References:	Emilie Verdon (IRC) Kenneth Dodd (USGS) - expert on the genus Terrapene Verdon, E . 2004. Activity patterns, habitat use, and home range of the Florida box turtle (Terrapene carolina bauri) in the lower Florida Keys. M.S. Thesis. Florida International University. Miami. 129 pp. Verdon, E., and M.A. Donnelly. 2005. Population structure of Florida Box Turtles (Terrapene carolina bauri) at the southernmost limit of their range. Journal of Herpetology 39(4).

GGG. *American alligator (Alligator mississippiensis)*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	American alligator (Alligator mississippiensis)
Monitoring Question(s):	What is the relative distribution, abundance, body condition, alligator hole occupancy, nesting level, and demographic structure of alligators in various habitats in relation to water levels and salinities throughout Everglades National Park and Big Cypress National Preserve? How do these metrics change over time and during Everglades restoration?
Justification:	The American alligator is considered an ecosystem engineer in the Greater Everglades due to it role in maintaining alligator holes (aquatic refugia in the dry season). Additionally, it is a top predator and can influence many other species. Alligators have been monitored as a keystone species in the Everglades for over the last 20 years trying to link their population dynamics to resource management activities; especially to water management.
Metric:	Animals/km, Sex ratio, Size distribution, Body condition index, alligators per hole, nests/km2, All metrics are equivalent to those used as performance standards in Comprehensive Everglades Restoration Plan (CERP).
Method:	See Rice et al. 2005 for justification. Protocols are present in Alligator MAP annual reports as well as CESI Alligator distribution project reports. Nesting protocols are present in ENP's SRF protocols. Distribution, abundance, and demographic structure are obtained through night-light survey along airboat trails and canals. Body condition is measured by morphometric measurements of captured and released animals. Alligator hole occupancy and nesting effort are estimated through aerial survey via helicopter along line transects.
Frequency:	Annual
Timing:	Night-light surveys are currently performed during mid-dry season (March-April) and mid-wet season (September-October). Body condition is measured during April and October to correspond with dry and wet seasons respectively. Nesting effort is obtained during July-September. Hole occupancy transects are performed during dry season (February-May).
Scale of Collection:	Park-wide
Scale of Operation:	Park-wide

Scale of Analysis:	Park-wide, by park region.
Basic Assumptions:	All metrics other than body condition assume that data collection provides estimation of detection probability (alligator eyeshine, alligator presence in holes, nests). This is accomplished through design of monitoring using distance sampling, transect methodology, and/or direct estimation of detection. Body condition assumes population specific models of body growth (see Zweig 2004).
Research Needs:	Work is currently underway funded by CESI and MAP to address detection under the various monitoring components.
Management Goal:	With the resumption of natural patterns of volume, timing, and distribution of flow to the Everglades, the American alligator is expected to repopulate and resume nesting in the rocky glades and the freshwater reaches of tidal rivers in the mangrove estuaries and will increase in population size and body condition throughout most of ENP. In BICY, no current targets are identified other than maintenance of current population condition.
Threshold Target:	Historical data exist to provide estimates of natural annual variation. These data have not been used to set threshold targets.
Response:	Habitat restoration as necessary.
Constraints:	Continued priority of monitoring program.
Status:	On-going. Is an indicator in the Comprehensive Everglades Restoration Plan (CERP) Monitoring and Assessment Plan (MAP) and Interim Goals.
Estimated Cost:	Approximately 6 man-hours per night-light survey (4 per transect per year), 20 man-hours per body condition survey (2 per region monitored per year), 10-20 hours helicopter time and man-hours per year for hole occupancy monitoring, see NPS SRF protocols for nesting effort estimate.
References:	Rice, Ken G., Mazzotti, Frank J., and Brandt, Laura A. 2005. Status and Conservation of Florida Amphibians and Reptiles. Status of the American Alligator (Alligator mississippiensis). Pages 145-153 In W.E. Meshaka and K.J. Babbitt, eds. Status and Conservation of Florida Amphibians and Reptiles. Krieger Publishers, Melbourne, Florida. Zweig, C.L. 2003. Body condition index analysis for the American alligator. MS Thesis. University of Florida. Gainesville, FL 58pp.

HHH. *Land Birds - residential and migratory*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior
☑ Mangroves ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Land Birds - residential and migratory
Monitoring Question(s):	Is abundance and distribution of land birds changing?
Justification:	Birds have been shown across many scales to be good indicators for ecosystem health and integrity.

	Birds are early responders to change across the landscape, responding quickly in foraging and nesting patterns to both habitat degradation and to habitat improvement and restoration. In addition to residential birds, both US Virgin Islands and South Florida are important migratory stop-overs for many bird species and provide over-wintering habitat to some.
Metric:	Population abundance and distribution
Method:	Point counts (distance sampling) by habitat Complimented by netting if necessary
Frequency:	Quarterly to annual
Timing:	Population monitoring during breeding and non-breeding seasons
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Multiple Parks
Basic Assumptions:	Surveys reflect bird population abundance - requires appropriate timing and methodology
Research Needs:	How vegetation changes resulting from hydrologic restoration, exotic species invasions, and fire management alter bird abundance How sea level changes impact coastal forest land birds How natural disturbances (i.e. hurricanes, drought, flooding) impact land birds
Management Goal:	Maintain or increase non-breeding and breeding land bird population levels
Threshold Target:	Partners in flight, NABCI population and habitat objectives
Response:	Reduce impacts of principle stressors: Hydrologic alteration, improved fire management, exotic control, prohibiting/controlling pets in sensitive areas Collaborate with other agencies
Constraints:	Land bird range use is outside park system boundaries Water management control is determined by many competing concerns Fire management restrictions/constraints Precision of the sampling design to estimate populations and costs of high precision sampling design
Status:	Depends on habitat -pinelands is On-going
Estimated Cost:	Consult Gary Slater
References:	Gary Slater, M. Epstein, J. Lorenz, J. Browder, Florida Audubon, Keith Watson

III. *Land birds - Mangrove - population abundance and distribution*

Which conceptual model(s) is this indicator linked to?

☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Land birds - Mangrove - population abundance and distribution
Monitoring Question(s):	Is abundance and distribution of land birds in mangroves changing? Do climate change (sea level -rise), invasion by exotic plants (e.g., Schinus) and animals (i.e, Rattus), and/or management activities(i.e., hydrology/fire) affect population trends? How do natural disturbances (i.e, drought, hurricanes) affect population trends?
Justification:	The national parks (coupled with state parks and 10000 Islands NWR) contain some of the largest, most intact tracts of mangrove forest left in North America. However little is known about the ecology of mangrove ecosystems and especially mangrove landbirds, of which several are thought to be at risk of becoming endangered (e.g. White-crowned pigeon and Florida Prairie Warbler). Birds in general have been shown across many scales to be good indicators for ecosystem health and integrity.
Metric:	Avian population abundance (density) and distribution. Measuring habitat variables (vegetation, hydrology) should be collected at regular intervals.
Method:	Three general types of mangrove forest are recognized in this region: riverine forest, fringing forest (including mangrove islands occurring in bays and along the Florida Keys), and basin forests (which lie inland of riverine and fringing forests) (Odum and McIvor 1990). Differences among forest types are mostly due to variation in hydrologic flushing, which leads to differences in nutrient retention and, ultimately, physiognomy. Sampling points should be randomly selected and stratified among these three types of forest to control for this variation. Because we lack a priori information on the density of birds among our strata, we will attempt to locate an equal number of survey points within each stratum. In riverine forests, survey locations will consist of a line of points running longitudinally along tidal creeks. In fringing and basin forests, points will be randomly placed within the available habitat. In all cases, points will be separated by at least 150 m. Results from several years (1999-2003) of avian monitoring at Ten Thousand Island National Wildlife Refuge (Terry Doyle, unpubl. data) provide the basis for much of the methodology. . A pilot study at Ten Thousand Island National Wildlife Refuge revealed that the best time for breeding surveys was between 1 May and 15 June, as detection rates remained uniform over this period, and that 10-minute surveys were appropriate. Each sampling point will be visited once each year and counts will be conducted between sunrise and 10:00AM, as long as weather conditions remain suitable. During the ten-minute survey, observers will note all birds detected and record distances. Each point count should be broken down into 2-minute intervals, with each detected individual occurring within only one interval. Abundance can be measured using the time-of-detection method (Farnsworth et al. 2002). Results of this method can then be compared with Distance Sampling, as there are some concerns about the efficacy of using distance sampling in mangrove habitats (Pacifici et al., unpublished report). Like distance sampling, the time-of-detection method is an empirical modeling technique that accounts for variation in the detectability of birds at survey points (index-count metrics assume that counts are a consistent proportion of total abundance), but unlike distance sampling it does not require observers to estimate the exact distance to singing birds, which can be both difficult and imprecise. Rather, the time-of-detection method treats point counts like a removal experiment, in which birds are "trapped" (counted) during discrete "trapping sessions" (intervals during the point count) and removed from the population (not counted in subsequent intervals). The decline in numbers "trapped" through time can be used to estimate detectability (via the use of mark-recapture software such as Program SURVIV (White 1983)), which in turn can be used to estimate initial population size, or abundance.
Frequency:	Annual
Timing:	Population monitoring should be conducted during breeding and non-breeding seasons. Some type of monitoring, possible mist-net station, should be considered for migration period.
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks), Site Specific. Processes may vary among parks(i.e. salinity differences between Florida Bay and Biscayne Bay)
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific, Other (Please specify):

	Assuming sample size is large enough in individual parks.
Basic Assumptions:	Surveys reflect bird abundance
Research Needs:	How bird abundance is influenced through vegetation changes, hydrologic restoration, exotic species invasions, and fire management? How sea level changes impact coastal forest land birds How natural disturbances (i.e. hurricanes, drought, flooding) impact land birds
Management Goal:	Maintain or increase non-breeding and breeding land bird population levels
Threshold Target:	Partners in flight, NABCI population and habitat objectives.
Response:	Hydrologic alteration, improved fire management, exotic control
Constraints:	Landbirds should serve as ideal indicator: Parks contain the largest, most intact tracts of mangrove forest left. Fate of many mangrove landbirds is in NPS hands. Birds have been shown across many scales that they are good indicators for ecosystem health and integrity
Status:	Monitoring has been proposed. Lloyd, J. L. and G. Slater. 2006. Proposal to Florida Non-game program. Abundance, population status, and breeding-season habitat requirements of mangrove landbirds in southern Florida. Slater, G. L. and J. L. Lloyd. 2005. Proposal to CESI. Mangrove Landbirds in Everglades and Biscayne National Parks: Status, Distribution, and Habitat Relationships.
Estimated Cost:	For only population surveys during breeding and non-breeding seasons [i.e., no habitat sampling (vegetation, fire history, hydrology), cost for representative surveys >100 points/park (EVER, BICY, BISC ~ $30,000 - $50,000); Costs in Caribbean Parks unknown. Consult: Gary Slater
References:	Gary Slater Department of Interior. 2004. Science plan in support of Everglades restoration, preservation, and protection in south Florida. U.S. Department of Interior, Homestead, FL. Doyle, T. and G. L. Slater. Bird Monitoring Protocol for Mangrove Forest Ecosystems. Farnsworth G.L., K.H. Pollock, J.D. Nichols, T.R. Simons, J.E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk 119:414-25. U.S. Fish and Wildlife Service. 1999. The south Florida multi-species recovery plan: Mangroves. Ecological Services Office, Vero Beach, FL. U.S. Fish and Wildlife Service. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia, USA. Watson, J. K. 2003. DRAFT - Avian Conservation Implementation Plan, Everglades National Park. National Park Service, Southeast Region.

JJJ. *Landbirds - Pine Rockland - population abundance and distribution.*

Which conceptual model(s) is this indicator linked to?

☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Landbirds - Pine Rockland - population abundance and distribution.

Monitoring Question(s):	Is abundance and distribution of land birds in pine rocklands changing? Does management activities(i.e., hydrology/fire) affect population trends? How do natural disturbances (i.e, drought, hurricanes) affect population trends?
Justification:	The remaining pine rocklands, an important upland habitat and a globally imperiled ecosystem, are almost entirely found within Everglades National Park and the southeast corner of Big Cypress (with some remnants in the Bahamas). Habitat loss, altered fire regimes and altered hydrologic regimes have contributed to the extirpation of 7 breeding bird species within pine rocklands in Everglades National Park, 5 of which are cavity-nesting species. Efforts are underway to re-establish two of these species (eastern bluebird and brown-headed nuthatch) with hopes of later re-establishing others. Fire management, water management, and invasive species management are anticipated to affect pine rockland species.
Metric:	Avian population abundance (density) and distribution. Measuring habitat variables (vegetation, fire history, hydrology) should be collected at regular intervals.
Method:	Randomly established survey points under the criteria that 1) stations are > 350 m apart, and 2) stations are surrounded by at least 100 m of contiguous pine forest. Based on data that have been collected from bird surveys in the pine rocklands in Florida, 150 survey points allow us to estimate the density of most species with a coefficient of variation (CV) no greater than 20%. Seven-minute surveys will be conducted at each survey station, during which observers will record the radial distance from the sampling station to all birds detected visually or aurally. Surveys will be conducted by trained individuals between sunrise and 10:00AM as long as weather conditions remain suitable. Each station will be visited once per season between 15 April and 1 June (breeding season) and 15 December - 15 February (non breeding season). Using data from point counts, density is estimated using distance-sampling software (Laake et al.1994, Buckland et al. 2001). Distance sampling is an empirical modeling technique that accounts for variation in the detectability of birds at survey points (index-count metrics assume that counts are a consistent proportion of total abundance). Slater, G. L. 2001. Final Report: Avian Restoration in Everglades National Park: Phase II. Pp 59. National Park Service, Homestead, FL.
Frequency:	Annual, Other (Please specify): At this time it is unclear whether surveys would have to be completed annually. With power analyses, it could easily be determined the sampling needs necessary to detect population changes (this will likely be conducted as part of existing funding)
Timing:	At a minimum, data collection should occur during the breeding and non-breeding seasons. Some consideration should be given to migration surveys. Migrating birds consistently use pine rockland/hardwood hammock ecotones. One possible alternative is to use mist net stations to sample migrating landbirds.
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Multiple Parks, Site Specific Inference could be made within parks if sampling intensity high enough within individual parks
Basic Assumptions:	Surveys reflect bird abundance.
Research Needs:	How vegetation changes resulting from hydrologic restoration, exotic species invasions, and fire management alter bird abundance? How natural disturbances (i.e. hurricanes, drought, flooding) impact land birds?
Management Goal:	Maintain or increase non-breeding and breeding land bird population levels?

Threshold Target:	Partners in flight, NABCI population and habitat objectives.
Response:	Improved fire management, hydrologic alteration, exotic control
Constraints:	In general, the majority of pine rocklands are protected by National Parks, thus surveys would effectively sample the south Florida population. Fire management restrictions/constraints Water management control is determined by many competing concerns
Status:	Avian community monitoring in pine rocklands is ongoing in Everglades NP and Big Cypress NP for two objectives: 1) Monitoring reintroduced cavity-nesting populations. Surveys have been conducted in Long Pine Key, EVER (reintroduced site) and Raccoon Point, BICY (high quality reference site) during period 2001 - 2003 and were re-initiated in 2005 with current funding available to continue project through 2007. From 2005-2007 surveys include non-breeding season. 2) Investigate effects of fire management treatments. Surveys began in 2006 and funding will continue through 2009 for two additional sites in Big Cypress (Addition, Stairsteps) and in areas outside NPS lands (Florida Panther Refuge, Miami Dade county). Funding not in place to continue surveys in EVER or in Raccoon Point, BICY (Objective 1) in 2009.
Estimated Cost:	For only population surveys during breeding and non-breeding seasons [i.e., no habitat sampling (vegetation, fire history, hydrology), cost for representative surveys across EVER and BICY would run ~ $30 - 50,000; Consult: Gary Slater
References:	Gary Slater Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., and Thomas, L. (2001). Introduction to distance sampling. (Oxford University Press: New York.) Slater, G. L. 2004. Annual Report: Avian Restoration in Everglades National Park: Phase III. Pp 35. National Park Service, Homestead, FL. Slater, G. L. 2001. Final Report: Avian Restoration in Everglades National Park: Phase II. Pp 59. National Park Service, Homestead, FL.

KKK. *Landbirds-Cavity-nesting pine rockland birds - Demographics (Fecundity and Survival)*

Which conceptual model(s) is this indicator linked to?

☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Landbirds-Cavity-nesting pine rockland birds - Demographics (Fecundity and Survival)
Monitoring Question(s):	Are vital rates of abundance and distribution of land birds changing? Do management activities (i.e., hydrology/fire) affect vital rates? How do natural disturbances (i.e. el nino-la nina cycles, drought, hurricanes) affect vital rates?
Justification:	This indicator compliments the "Landbirds-pine rocklands-population abundance and distribution" indicator. Habitat loss, altered fire regimes and altered hydrologic regimes have contributed to the extirpation of 7 breeding bird species within pine rocklands in EVER, 5 of which are cavity-nesting bird species. Efforts are underway to re-establish two of these species (eastern bluebird and brown-headed nuthatch) with hopes of later re-establishing others. Fire management, water management,

	and invasive species management are anticipated to affect these species. Monitoring fecundity and nestling survival provides an early indicator of the habitat quality of a site and causes of change.
Metric:	Fecundity (clutch size, hatching rate, # of young produced, adult and juvenile survivorship). Measuring habitat variables (vegetation, fire history, hydrology) should be collected at regular intervals.
Method:	Slater, G. L. 2004. Final Report: Avian Restoration in Everglades National Park: Phase III. Pp 59. National Park Service, Homestead, FL.
Frequency:	Every 2-3 years, Other (Please specify): or after major weather events/catastrophes
Timing:	Breeding Season (March - June)
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks), Park-wide, Site Specific (Fire management practices varied among parks (BICY vs. EVER)
Scale of Analysis:	Multiple Parks, Site Specific Inference could be made within parks if sampling intensity high enough within individual parks
Basic Assumptions:	Vital rates reflect habitat condition
Research Needs:	How vital rates (and hence population persistence) are influenced through vegetation changes, hydrologic restoration, exotic species invasions, and fire management? How natural disturbances (i.e. hurricanes, drought, flooding) affect vital rates (and hence population persistence land birds?
Management Goal:	Maintain or increase vital rates at level that insures population persistence.
Threshold Target:	Insufficient knowledge
Response:	Improved fire management, hydrologic alteration, exotic control
Constraints:	As the apparently most vulnerable group of pine rockland landbirds (5 extirpated from EVER), vital rates at levels that insure population persistence should be ideal indicator for this system. Without information on vital rates, understanding population trends is impossible. Birds have been shown across many scales that they are good indicators for ecosystem health and integrity
Status:	Monitoring ongoing for two reintroduced species (Brown-headed Nuthatch, Eastern Bluebird) in Everglades National Park 1997-2003, and 2005. Funding to continue work in place through 2007. In Big Cypress, data available from 1997-2003.
Estimated Cost:	Costs would run ~ $10-15,000 per site (e.g., Long Pine Key); Consult: Gary Slater
References:	Gary Slater Slater, G. L. 2004. Annual Report: Avian Restoration in Everglades National Park: Phase III. Pp 35. National Park Service, Homestead, FL. Slater, G. L. 2001. Final Report: Avian Restoration in Everglades National Park: Phase II. Pp 59. National Park Service, Homestead, FL. Watson, J. K. 2003. DRAFT - Avian Conservation Implementation Plan, Everglades National Park. National Park Service, Southeast Region.

LLL. *Colonial Nesting Birds (e.g. Least terns, pelicans, boobies, roseatte terns, egrets, storks, herons)*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior
☑ Mangroves ☑ Florida Bay

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑
DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Colonial Nesting Birds (e.g. Least terns, pelicans, boobies, roseatte terns, egrets, storks, herons)
Monitoring Question(s):	Are population sizes, nest success, and distribution of wading birds and sea birds changing? Effects of contaminants if appropriate to the species?
Justification:	The status of colonial nesting bird colonies, their size and nesting success, reflect the amount and quality of fish and/or invertebrates available in the surrounding landscape/seascape, plus the quality of habitat and freedom from predators in the immediate nesting areas. They also bioaccumulate certain contaminants in their feathers, blood, and eggs. Because of their sensitivity to landscape health, fishery health, and contaminants, colonial nesting birds are almost all either federal or state threatened species, endangered species or species of special concern.
Metric:	Nesting Population size, nesting success/recruitment, distribution Contaminants if a locality/species concern
Method:	Aerial/ground/boat rookery surveys-nest success, numbers of nests, number of adults Feather/blood samples if contaminants are a concern
Frequency:	Every Year - Weekly during nesting season. Monthly to determine when nesting season begins
Timing:	Monthly year-round. Then increased to weekly during nesting season.
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks, Site Specific
Scale of Operation:	Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Basic Assumptions:	Success of nesting colonies and recruitment of juveniles into the breeding colony are related to habitat quality, availability of prey base, invasive species, water management and extreme weather system impacts
Research Needs:	Movement patterns Recruitment Distribution Foraging As our fishery improves due to Marine Protected Area status, does this in turn result in improvement in population growth, # of chicks fledging As our water management in south Florida improves, does this in turn result in improvement in population growth, # of chicks fledging
Management Goal:	Maintain or increase average bird population levels, have birds reestablish rookeries in traditional areas where they are currently absent
Threshold Target:	To be determined. Since many of these are Federal T & E species, this requires consultation with US Fish and Wildlife Service
Response:	Pest control around nesting locations Habitat enhancement Water management alterations
Constraints:	Manpower limited
Status:	On-going

	Note: The Comprehensive Everglades Restoration Plan has "System-Wide Wading Bird Nesting Patterns" as a CERP Interim Goals Indicator and monitoring variables in the CERP Monitoring and Assessment Plan.
Estimated Cost:	Dependent on numbers of populations
References:	Judy Pierce (DPN-Div of Fish and Wildlife), Sony Bass (EVER), Gary Slater (BICY)

MMM. *Wading birds - Regional South Florida - Systematic Reconnaissance Flights*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior
☑ Mangroves

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Wading birds - Regional South Florida - Systematic Reconnaissance Flights
Monitoring Question(s):	Are population sizes and distribution of wading birds changing?
Justification:	This indicator compliments the "colonial nesting birds" indicator but is applicable to Everglades National Park and Big Cypress parks only. As Everglades, Big Cypress and the surrounding landscape are such large areas, the Systematic Reconnaissance Flights program provides a regional estimation of populations in south Florida that compliments rookery surveys but is more cost-effective across such wide areas. Wading bird abundance and distribution reflect the amount and quality of fish and/or invertebrates available in the surrounding landscape/seascape, the quality of habitat and freedom from predators in the immediate nesting areas, and contaminant levels. Because of their sensitivity to watershed health, and contaminants, native wading birds are almost all Florida species of special concern with wood storks listed as federally endangered.
Metric:	Abundance and distribution
Method:	Systematic Reconnaissance Flight (SRF) wading bird survey -population monitoring via 500m airplane belt transects
Frequency:	Annual, Conducted annually December-May and October
Timing:	Population monitoring during wet and dry periods
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Park-wide
Basic Assumptions:	Wading bird populations and recruitment are related to hydrology
Research Needs:	Movement patterns
Management Goal:	Maintain or increase average wading bird population levels, have wading birds reestablish rookeries in traditional areas where they are currently absent
Threshold	Insufficient knowledge

Target:	
Response:	Hydrologic alteration toward more natural system conditions
Constraints:	Wading bird range use extends outside park system boundaries Water management control is determined by many competing concerns
Status:	On-going Note: The Comprehensive Everglades Restoration Plan has "System-Wide Wading Bird Nesting Patterns" as a CERP Interim Goals Indicator and monitoring variables in the CERP Monitoring and Assessment Plan.
Estimated Cost:	annual cost for EVER $40000
References:	Sonny Bass, Jerry Lorenz. Marilyn Spalding, Peter Frederick

---

NNN. *Bats - USVI*

Which conceptual model(s) is this indicator linked to?

☑ Island Interior ☑ Mangroves

Parks where monitoring would be conducted

☑ BUIS ☑ SARI ☑ VIIS

Indicator:	Bats - USVI
Monitoring Question(s):	Are changes occurring in bat populations, foraging activity levels, and bat roosting locations with special attention to the red fruit bat, Stenoderma rufum (the rarest bat in the USVI), and the fisherman bat, Noctilio leporinus ?
Justification:	Six bat species are the only native terrestrial mammals in the U.S. Virgin Islands. Although none are locally endemic, four are listed as "Species of Greatest Concern" in the Comprehensive Wildlife Strategy for the U.S. Virgin Islands. Their role in local plant pollination and effects on local insects and fish populations are unclear but could be important.
Metric:	Roost locations and roost population counts Relative activity levels
Method:	Location of bat roosts and counts of adults leaving roosts Use of ANABAT system to establish relative activity levels in foraging areas and water areas. Mist netting used to confirm species identification.
Frequency:	Annual, Initially ever year for first 4-5 years to create baseline, then reduce frequency to once every 2-5 years as appropriate depending on data variability.
Timing:	To Be determined
Scale of Collection:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Scale of Operation:	Park-wide, Site Specific
Scale of Analysis:	Park-wide, Site Specific
Basic Assumptions:	Any use of ANABAT assumes that bat species and calling frequency can be related to the species and activity levels. This must either be based on previous work or by coupling mist-netting and/or roost searches with Anabat work.

Research Needs:	Research needed into roosting preferences, dietary activities, and habitat requirements of bats with special focus on Stenoderma rufum and Noctillio. Other research needed is their role in plant distribution and pollination.
Management Goal:	Maintain populations that roost within park boundaries and contribute to maintenance of bat populations that forage within the park but roost outside boundaries.
Threshold Target:	Insufficient knowledge
Response:	Protection of roosts. Other actions likely related to maintenance of plants or prey base the bats forage upon.
Constraints:	Roosts for bat populations in Buck Island Reef National Monument and Salt River National Historic Site and Ecological Reserve may be outside park boundaries although this is unknown at this point. Researchers who handle bats (i.e. during mist-netting activities) should be vaccinated against rabies.
Status:	No ongoing bat monitoring is occurring. An NPS-funded inventory was conducted using ANABAT SONAR in 2001 but no roost surveys were conducted. Results are pending. "Previous studies of bats in the USVI include anecdotal comments on their identification, distribution, and ecology (e.g., Starrett 1962, Koopman 1975), studies on the ecology, behavior, and physiology of the Cave Bat (Bond and Seaman 1958, Nellis 1971, McManus and Nellis 1972, Ehle 1977, Nellis and Ehle 1977) and Fruit Bat (Ehle 1977), and the evaluation of bat detectors and radio tracking for studying bats (Knowles 1992a, b). Recent surveys have been conducted on St. John (Gannon 2003) and St. Croix (G. Kwiecinski, pers. comm.). Efforts are underway through IRF and the University of Scranton to initiate inventory and population studies of bats on the northern USVI." (from Comprehensive Wildlife Strategy for the U.S. Virgin Islands, 2005, http://www.vifishandwildlife.com/Wildlife/05F01WildlifePlan/Part%201%20Introduction/table%20of%20contents.htm)
Estimated Cost:	Approx. $40-80,000 per sampling year (???)
References:	U.S. Virgin Islands Department of Planning and Natural Resources Division of Fish and Wildlife. 2005. Comprehensive Wildlife Conservation Strategy for the U. S. Virgin Islands. June 1. 2005. 216 pages. URL: http://www.vifishandwildlife.com/Wildlife/05F01WildlifePlan/Part%201%20Introduction/table%20of%20contents.htm

OOO. *Florida panther*

Which conceptual model(s) is this indicator linked to?

☑ Forest Uplands and Wetlands

Parks where monitoring would be conducted

☑ BICY ☑ EVER

Indicator:	Florida panther
Monitoring Question(s):	What is the abundance and distribution of Florida Panthers? How is it changing over time?
Justification:	Florida panthers are a top predator in the south Florida region, whose primary prey are deer, but

also include large fish, birds, feral hogs, etc. They are a federally endangered species that has been impacted by habitat loss and fragmentation, roadkill, contaminant bioaccumulation, and genetic bottlenecks. This sub-species is currently found only in south Florida. Big Cypress, neighboring state lands, and portions of Everglades are key areas for its conservation and recovery. Monitoring information is used to assess population status and trends and distribution information is used to inform park management about potential impacts of visitor use activities and management activities on panther distribution and relative activity levels.

Metric:	Population abundance and distribution
Method:	Capture, radio-telemetry, remote-camera surveys, scat survey
Frequency:	Every 2 years
Timing:	Scat surveys during dry season, radio-telemetry any time, remote-camera any time probably spring
Scale of Collection:	Regional (incl. areas outside parks)
Scale of Operation:	Regional (incl. areas outside parks)
Scale of Analysis:	Regional (incl. areas outside parks)
Basic Assumptions:	
Research Needs:	Panther kitten survival and dispersal
Management Goal:	Maintain or increase panther population levels
Threshold Target:	Consult Florida Panther Recovery plan (USFWS)
Response:	Dependent upon identified cause
Constraints:	Panther range use extends outside park system boundaries Private land development issues
Status:	Radio-telemetry On-going Some camera survey work ongoing, needs to be expanded
Estimated Cost:	
References:	Darrel Land (FFFWC), Sonny Bass, Deb Jansen

PPP. *Visitor Use (Both commercial and individual/personal use)*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior
☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑
DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Visitor Use (Both commercial and individual/personal use)
Monitoring Question(s):	How do people use the park? How many? Where? When? What are the impacts of these individual activities? Are these activities impairing the integrity of the ecosystem?
Justification:	Parks must provide for both the enjoyment of the resources by the public coupled with conservation of the resources for future generations. However, visitor use, if unmanaged, can impact and alter resources in unsustainable ways. Being able to relate visitor use to impacts on resources helps management to meet both these park objectives.
Metric:	Activities Demographics Person days Spatial Distribution/ Density Numbers of people/cars/boats - both commercial and private
Method:	Surveys (sociological, aerial, etc) Questionnaire Census Counts Model development and use Commercial operator numbers
Frequency:	Continuous: for visitation, other survey may be less frequent
Timing:	Year-round, stratified weekdays, weekends, night, holidays
Scale of Collection:	Multiple Parks
Scale of Operation:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Scale of Analysis:	Regional (incl. areas outside parks), Multiple Parks, Park-wide, Site Specific
Basic Assumptions:	Monitoring reflects the population- appropriate timing and methodology Complex Dimensions
Research Needs:	N/A
Management Goal:	Ensure that activities aren't impairing the integrity of the ecosystem Optimize visitor experience over time
Threshold Target:	Insufficient Knowledge
Response:	Reduce impacts of principal stressors:

Collaborate with other agencies
Internal response- regulate human activities if impairment is identified

Constraints: OMB

Status: Ongoing, needs improvement

Estimated Cost: Park specific- based on last year visitation numbers
~$0.50-$1.00/person

References: Contact: G. Mackless (NPS), B. Leeworthy, Bhat, FIU, NOAA NOS, Alyse Getty NPS Contractor - Parsons

QQQ. *Land Development inside/outside the park (within 5 mile radius for USVI parks, radius may be expanded to 75 miles in South Florida)*

Which conceptual model(s) is this indicator linked to?

☑ Freshwater Wet Prairies and Marshes ☑ Forest Uplands and Wetlands ☑ Island Interior ☑ Mangroves ☑ Florida Bay ☑ Biscayne Bay ☑ Coastal Shelf/Deep Oceanic

Parks where monitoring would be conducted

☑ BICY ☑ BISC ☑ BUIS ☑ DRTO ☑ EVER ☑ SARI ☑ VIIS

Indicator:	Land Development inside/outside the park (within 5 mile radius for USVI parks, radius may be expanded to 75 miles in South Florida)
Monitoring Question(s):	How do activities outside the park affect the park? Development-Municipal, private, commercial Land Use Agricultural Point Source Pollution Roads/habitat fragmentation Utilities Lighting & noise
Justification:	With increasing development both within and outside of the parks there is an urgent need to identify land use changes that could impact the park, changes in the size of the non-urban buffer area around park boundaries, as well as changes in connectivity with other conserved natural areas. All of these changes have a significant impact upon park resources. Monitoring of changes over time would allow parks to understand the effects of these changes and to take appropriate actions to mitigate impacts.
Metric:	Activities Demographics Spatial Distribution/ Density Landscape Change
Method:	Cooperation with other agencies/NGO's (data-mining) Surveys (sociological, aerial, etc) Census Model development and use Aerial photography Combined with local zoning information Permit review by NPS
Frequency:	5-10 years based on management review cycle
Timing:	As data becomes available
Scale of Collection:	Regional
Scale of Operation:	Regional
Scale of Analysis:	Regional
Basic Assumptions:	Monitoring reflects the population- appropriate timing and methodology Complex Dimensions Habitat conversion/development within the parks and up to 5 miles away from parks (75 miles in S. Florida) will impact the park resources

Research Needs:	Uncertainty of known protocol
Management Goal:	Understand how outside activities are affecting the park Optimize visitor experience over time Have USVI go to one tier Coastal Zone Management system
Threshold Target:	NA
Response:	Park management is responsive and aware to outside influences
Constraints:	Dependence on outside agencies/organizations for data, management, and response
Status:	Ongoing, needs improvement
Estimated Cost:	NA
References:	Contact: Census Bureau, County Records, State, Federal, NGO's, Army Corps, DEP, FWC, USDA, Dept of Commerce